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Ground Water In The Republican River Basin in Nebraska- Part 1: Nuckolls, Webster, Franklin and Harlan Counties

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PART I

NUCKOLLS, WEBSTER, FRANKLIN AND HARLAN COUNTIES

H. A. Waite, E. C. Reed and D. S. Jones, Jr.

Prepared by the Conservation and Survey Division of the University of Nebraska, the United States Geological Survey and the Bureau of Irrigation, Water Power and Drainage of the Nebraska Department of Roads and Irrigation

NEBRASKA WATER RESOURCES SURVEY
WATER SUPPLY PAPER 1

The UNIVERSITY OF NEBRASKA
Conservation and Survey Division

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by H. A. Waite, E. C. Reed and D. S. Jones, Jr.

In June, 1939, a comprehensive test-drilling program in the Republican River basin in Nebraska was begun by the Federal Geological Survey in cooperation with the Conservation and Survey Division of the University of Nebraska. The cooperative investigation has been carried on by personnel of the State and Federal agencies working under the general supervision of G. E. Condra, Dean and Director of the Conservation and Survey Division, Wardner G. Scott, State Engineer of Nebraska, and O. E. Meinzer, Geologist in charge, Division of Ground Water, U. S. Geological Survey. Much of the field work has been under the immediate direction of G. E. Condra, the late R. C. Cady, of the Federal Geological Survey, E. C. Reed, Associate State Geologist, and part of the work from 1942 until the present was supervised by Dan S. Jones, Jr., Assistant Chief of the Bureau of Irrigation, Water Power, and Drainage of the Nebraska Department of Roads and Irrigation and H. A. Waite, of the Federal Geological Survey. In 1942, the Nebraska Bureau of Irrigation entered into an agreement with the Conservation and Survey Division to participate in the cooperative ground-water program and assumed responsibility for the drilling program in the western half of the area.

During the course of the investigation, test holes were drilled in Nuckolls, Webster, Franklin, Harlan, Furnas, Red Willow, Hitchcock, Dundy, Chase, Hayes, and Frontier counties. Two portable hydraulic drilling machines, owned by the State and Federal Geological Surveys were used in the test-drilling. The drilling machines were operated by the following personnel: Howard Haworth, Harry Burleigh, Oliver Scherer, Robert Lawrence, Orville Hansen, Harry Pinneker, and Lee Cornelius, all members of the Conservation and Survey Division; and George Weill, Carl Krenzien, Joe Vance, and Harl Williamson, of the Bureau of Irrigation. The elevations of the test holes in the western part of the area were determined by instrumental levels run by V. F. Osborn and Harl Williamson of the Nebraska Bureau of Irrigation, while most of those in the eastern part were established with altimeters except a few that were estimated from U. S. Geological Survey topographic maps. Most of the field work in connection with this investigation was done during the years 1939, 1941, and 1942, but 18 test holes were drilled in 1933, 9 in 1934, and 4 in 1935.

In 1939 the test-drilling program was carefully coordinated with the investigation of the geology and ground-water resources of the Republican Valley in the southern half of Franklin, Webster, and Nuckolls counties 1/ and a report dealing with the cooperative drilling program in the Republican River Valley in Nebraska was prepared by H. F. Haworth. 2/

Altogether 765 test holes have been drilled in the Republican River basin with the two project-owned drilling rigs. Data relative to 20 core-drill holes put down in the Republican River basin in Nebraska by the Corps of Engineers, U. S. Army, in connection with a survey for flood control of the Republican River in Colorado, Nebraska, and Kansas and 42 test holes drilled in the basin in Nebraska by the U. S. Bureau of Reclamation in connection with prospecting for suitable dam foundations at proposed reservoir sites are also included in this report by special permission of these agencies.

Microscopic examination of the cuttings obtained from the cooperative test-drilling program was made by E. C. Reed. This report has been critically reviewed by O. E. Meinzer and others of the Federal Geological Survey, by G. E. Condra, Dean and Director of the Conservation and Survey Division, of the University of Nebraska, and by Wardner G. Scott, State Engineer of Nebraska. V. F. Osborn of the Bureau of Irrigation prepared the illustrations and assembled the logs of test holes for publication. The report and logs were typed by Miss Bernice Lundeen.

This report is designed to make available as much information as possible on ground-water conditions in the Republican River basin in Nebraska. The data herein assembled include three types of information (1) the records of test holes drilled in the county, (2) a map of the county showing (a) the locations and numbers of all of the test holes, (b) the contour of the top of the impervious bedrock platform and (c) the thickness of the water-saturated sand and gravel formations in the valley

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1/ Cady, R. C., Geology and ground-water resources of the Republican Valley in the southern half of Franklin, Webster, and Nuckolls counties: (To be published as a U. S. Geol. Survey Water-Supply Paper.)

2/ Haworth, Howard F., Drilling program in the Republican River Valley (1939) 24 pp., 12 figs., 1939. (In manuscript form on file in the office of the Conservation and Survey Division, Lincoln, Nebraska, and in the office of the Division of Ground Water, Geological Survey, Washington, D. C.

bottom land and terrace region, shown by means of shaded patterns on the county map, and (3) a geologic profile section in each county based on the test-drilling information. The description of materials drilled in the test holes is in driller's terminology and does not constitute, necessarily, an exact geologic description.

Interested parties can make use of these data advantageously in the following manner: The probable nature and thickness of materials underlying a specific piece of land can be approximated by studying the shaded areas on the map and by examining the logs of nearby test holes drilled in similar topographic positions, keeping in mind differences in surface elevation. If the land is situated in the upland outside of the valley, logs of nearby upland test holes can be used as a guide, provided that allowances are made for differences in surface elevation and variations in texture and slope of the water-bearing material.

The maps may be used in the following manner: If the land in question is located in an area shown on the map as underlain by a relatively thin, water-filled formation, the chances of obtaining high-capacity wells are less than in areas shown as underlain by a relatively thick water-filled formation. Thus, locations on the farm may be selected that are more favorable from a water-production standpoint.

The contours on the top of the relatively impervious Cretaceous bedrock theoretically connect points of equal elevation on the top of this buried surface and thus outline buried channels where the elevations are comparatively low and buried ridges where the elevations are comparatively high. As a general rule the thickest and coarsest sands and gravels occur near the middle of the buried channels.

All ground-water information shown on the maps is based on data obtained from test drilling and is therefore more accurate for land adjacent to closely-spaced test holes and less accurate for areas where the test holes are situated farther apart.

The thicknesses of saturated water-bearing material shown on the county Ground-Water Maps have been computed from water levels measured in the test holes on the dates specified in the written logs. It is known that the water table fluctuates upward and downward depending upon the amounts of ground-water recharge and discharge. This seasonal fluctuation is usually less than a foot and rarely more than three to four feet. Therefore the thicknesses shown are probably accurate within a few feet at any time of the year.

The information included in this report is not designed to eliminate the necessity of drilling test holes prior to the installation of irrigation or other high-capacity wells, but it should be a guide toward the evaluation of possibilities. Many factors other than the thickness of the water-saturated material greatly affect the yields of the wells and the perennial supplies of ground water in any locality, including: (1) permeability of the water-bearing formation, (2) design and construction of the well and pumping equipment, (3) ease of recharge of the water-bearing formation from precipitation or from surface flow, and (4) amount, distribution and nature of precipitation and of surface flow.

If additional technical assistance and guidance is required the Conservation and Survey Division of the University of Nebraska is equipped to answer inquiries on specific problems providing location by legal description is accurately supplied.

BEDROCK FORMATIONS IN NUCKOLLS, WEBSTER, FRANKLIN AND HARLAN COUNTIES

The surface and near-surface sediments in most of the area of Nuckolls, Webster, Franklin and Harlan counties consist of mantlerock materials such as (1) silty clays (loess) and (2) sands and gravels, both of which were deposited in comparatively late geologic time (Pleistocene age). The sands and gravels, deposited by streams, and the silty clays, deposited by wind action, form a mantle over the top of a relatively uneven, eroded bedrock surface. However, the present streams have cut through the mantlerock and exposed the underlying bedrock at a number of places, especially along the valley sides of the Republican River and tributary stream valleys.

Knowledge of the bedrock materials of the area has been gained by a study of the bedrock outcrops along the valley sides and the records and samples from deep wells, most of them drilled as tests for oil and gas. 1/

The bedrock formations which are exposed in this area, listed in order from youngest (uppermost) to oldest (lowermost) are; the Ogallala formation of Tertiary age; and the Pierre shale, Niobrara formation, and Carlile shale, of upper Cretaceous age. Older Cretaceous formations, which occur at depth within the area and are exposed east of the limits of the area of this report, are the Greenhorn limestone, Graneros shale, Dakota sandstone, Fuson shale and Lakota sandstone. These Cretaceous sedimentary rocks are underlain by a considerable thickness of older limestones, shales, sandstones, dolomites and similar types of sedimentary rocks of Permian, Pennsylvanian, Mississippian (?), Devonian, Silurian, Ordovician and Cambrian age, and they in turn are underlain by igneous or metamorphic rocks.

Before the Ogallala formation of Tertiary age was deposited the underlying Cretaceous formations were subjected to folding and then were eroded to a comparatively flat eastward sloping surface. As a result, the Ogallala in places rests on truncated Cretaceous rocks and may occur next above any part of the Pierre shale and Niobrara formation.

1/ Condra, G. E., Geology and water resources of Republican Valley, Nebraska, U. S. Geol. Survey Water-Supply Paper 216, 1907

Condra, G. E. and Reed, E. C., The geological section of Nebraska, Nebr. Geol. Survey Bull. 14, November, 1943

The Ogallala formation is made up of a series of hard and soft beds consisting of limy sandstone and siltstone interbedded with sands, some gravel, and some clay. Certain zones are extremely dense in places where the cementing material is silica. The Ogallala formation occurs immediately below the mantlerock under a large part of the uplands south of the Republican Valley in Harlan and Franklin counties thinning in an eastward direction, it occurs as scattered very thin deposits in southwestern Webster County, and is absent in Nuckolls County. The lime-cemented beds are locally called "magnesia rock" and some erroneously call the dense silica-cemented beds "granite." Certain unconsolidated zones of the Ogallala are relatively permeable and yield water to wells where the deposit occurs below the level of the water table. In many of its occurrences in this region, however, the Ogallala occurs above the water table and therefore is not a source of groundwater.

As stated above, the Cretaceous formations were folded and eroded prior to the accumulation of the sediments of the Ogallala formation. The Cretaceous rocks dip gently westward across Nuckolls, Webster, Franklin and eastern Harlan counties; they are relatively flat-lying in central Harlan County and dip eastward in western Harlan County. The long erosion period that followed the folding of the Cretaceous rocks removed all of the Pierre shale and variable amounts of the upper part of the Niobrara formation from the upfolded areas but preserved all of the Niobrara as well as the lowermost parts of the Pierre shale in the downfolded region in central Harlan County.

The Pierre shale is a dark gray to black shale in this area. Its occurrence, both surface and subsurface, is limited to a relatively small area in central Harlan County where only the lowermost part of the formation has been preserved. The Pierre shale is relatively impervious and yields water to wells only where it is jointed or fractured.

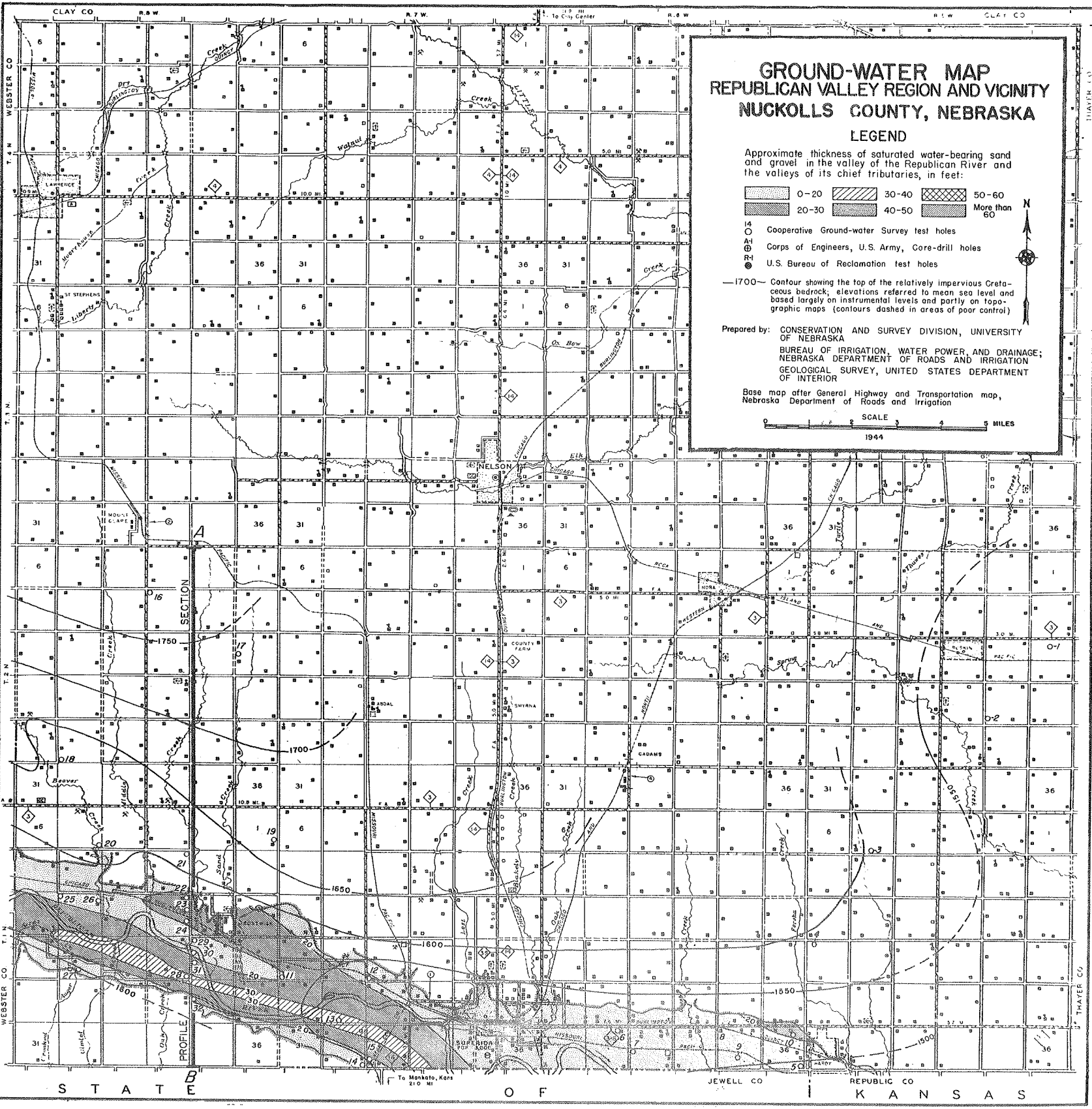
The Niobrara formation consists predominantly of chalky shale in its upper and middle parts, and chalky limestone in its lower part. It is approximately 400 feet in thickness where all of the formation has been preserved from erosion, as in central Harlan County, but increasing amounts of the upper part have been removed in an eastward direction. The formation has been completely removed in eastern Nuckolls County where older rocks are either exposed or are immediately below the mantlerock cover. The Niobrara formation is relatively impermeable and does not yield water to

wells except where it is jointed or fractured.

The Carlile shale underlies the Niobrara formation. It either is exposed or is present below the mantlerock formations in eastern Nuckolls County, and occurs at increasingly greater depths under the area to the west. It consists predominantly of a dark gray to black shale with some chalky layers in its lower part and locally with a thin sandstone (Codell sandstone member) at its top. In this area, the Carlile has an aggregate thickness of about 250 feet. The upper sandstone zone is a potential water-bearing formation in a part of the area, but it is not very reliable as it is absent in many places and too deep for ordinary farm wells in others. Some of the oil tests in Harlan County found water in this sandstone under artesian pressure at depths of 600 to 800 feet. Nothing definite is known about the quality of this water but it is probably mineralized to some extent especially where it occurs at depths of 300 feet or more. Better quality water is sometimes obtained at this horizon farther to the east where the sandstone occurs at shallower depth, but wells are generally weak.

The older Cretaceous rocks, which do not crop out in this area, but do occur at depth, are the Greenhorn limestone (about 30 feet in thickness), the Graneros shale (varying from 40 to 90 feet in thickness), the Dakota sandstone (about 150 feet thick), the Fuson shale (about 60 feet thick), and the Lakota sandstone (150 to 200 feet thick). Of these formations the Dakota and Lakota sandstones are the only ones which can be relied upon to furnish satisfactory quantities of ground water. However the Dakota sandstone occurs at depths ranging from about 350 feet in eastern Nuckolls County to 1000 feet or more in central and western Harlan County and the Lakota sandstone is about 200 feet deeper throughout the area covered by this report. The water from the Dakota and Lakota is here relatively highly mineralized and is often quite salty. The mineral concentration in the waters of the Dakota and Lakota is 10 to 15 times as great as the average, shallow, mantlerock water.

In general, there are better possibilities of developing adequate and good quality ground water supplies in the sands and gravels of the Pleistocene mantelrock in Nuckolls, Webster, Franklin and Harlan Counties than in the underlying bedrock formations.


GROUND-WATER MAP
REPUBLICAN VALLEY REGION AND VICINITY
NUCKOLLS COUNTY, NEBRASKA
LEGEND
Approximate thickness of saturated water-bearing sand and gravel in the valley of the Republican River and the valleys of its chief tributaries, in feet:
0-20
20-30
30-40
40-50
50-60
More than 60
Cooperative Ground-water Survey test holes
Corps of Engineers, U.S. Army, Core-drill holes
U.S. Bureau of Reclamation test holes
—1700— Contour showing the top of the relatively impervious Cretaceous bedrock; elevations referred to mean sea level and based largely on instrumental levels and partly on topographic maps (contours dashed in areas of poor control)
Prepared by: CONSERVATION AND SURVEY DIVISION, UNIVERSITY OF NEBRASKA
BUREAU OF IRRIGATION, WATER POWER, AND DRAINAGE; NEBRASKA DEPARTMENT OF ROADS AND IRRIGATION
GEOLOGICAL SURVEY, UNITED STATES DEPARTMENT OF INTERIOR
Base map after General Highway and Transportation map, Nebraska Department of Roads and Irrigation
SCALE
0 1 2 3 4 5 MILES
1944
N
CLAY CO
WEBSTER CO
THAYER CO
JEWELL CO
REPUBLIC CO
NELSON
SECTION A
PROFILE B
STATE OF KANSAS

GROUND-WATER CONDITIONS IN NUCKOLLS COUNTY

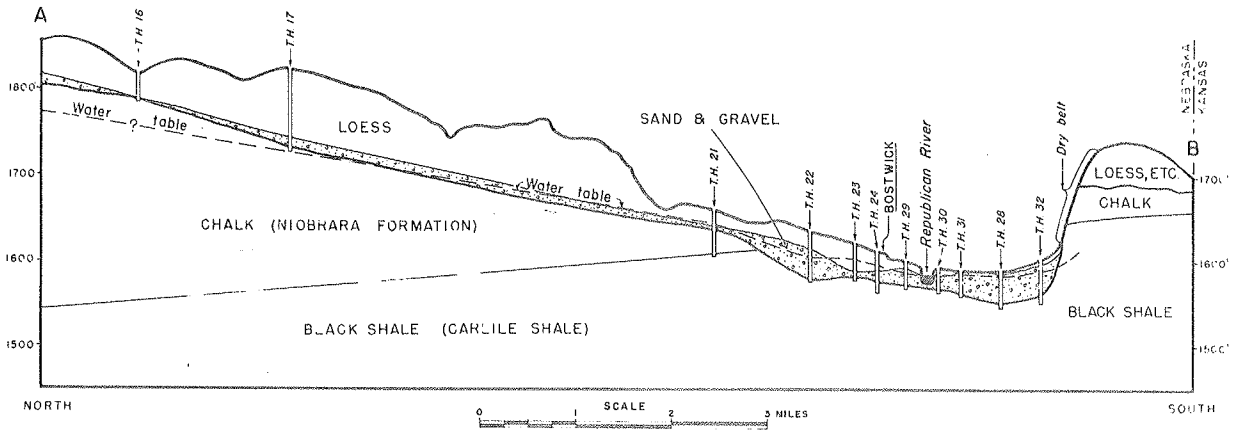
The southern half of Nuckolls County may be divided into three ground-water regions on the basis of thickness of water-filled sand and gravel: (1) the area north and northeast of the Republican Valley, (2) the Republican Valley, and (3) the area southwest of the Valley.

The region north and northeast of the Valley in Nuckolls County is typified by relatively shallow and high bedrock which consists of chalky shale and chalk of the Niobrara formation. This bedrock is overlain by a relatively thin mantle of sand and gravel capped by silty clay (loess). The comparatively small thickness of water-filled sand and gravel above the relatively impervious and high bedrock platform makes this region unfavorable for the development of ground-water supplies. Many farm wells in the area obtain water from the sand and gravel above the chalky shale bedrock, others are drilled into the upper part of the bedrock which yields water where it is fractured and jointed, and a few are drilled to deeper bedrock sandstones. Most of the wells in this region have rather low water-yielding capacity.

The Republican Valley is the most favorable area for ground-water development because here the impervious chalky shale bedrock has been scoured out more deeply and there is a greater thickness of water-bearing sand and gravel overlying the shale than on the upland areas outside of the Valley. Moreover, the water table (top of water-saturated zone) is relatively close to the surface. The approximate thickness of water-filled sand and gravel which underlie the Valley are shown on the Ground-Water Map of Nuckolls County. The deeper part of the buried, sand- and gravel-filled channel, as determined by test drilling, is in the southern part of the Valley not far north of the bluff line.

The small area southwest of the Republican Valley region is somewhat similar to the region north of the Valley because the chalky shale bedrock occurs high above the Valley level, the sand and gravel above the shale is relatively thin, or absent, and the water table is generally below the sand and gravel. Because of these conditions it is impossible to obtain an adequate supply of ground water in this region.

The conditions which exist in these three ground-water regions are shown graphically in the following geologic profile section:



Geologic Profile Section A-B. Location along a north-south line three-fourths mile west of Bostwick extending from a point 12 miles north of the Nebraska-Kansas line (A) southward to the Nebraska-Kansas line (b). Note (1) the relatively thin sand and gravel which occurs above the chalk bedrock north of the Republican Valley (2) the deeper buried channel in the Valley Region filled with thicker water-bearing sands and gravels (3) the unusually high chalk and shale bedrock south of the Valley and (4) the position of the water table, sloping southward toward the Republican Valley, as shown by the dashed line. The locations of the test holes are shown on the profile section and numbered (T.H.16, etc.) according to the numbers shown on the Ground-Water Map. The black shale shown in the profile section is the Carlile shale and the chalk is a part of the Niobrara formation.

LOGS OF TEST HOLES DRILLED IN NUCKOLLS COUNTY BY THE CONSERVATION AND SURVEY DIVISION AND THE FEDERAL GEOLOGICAL SURVEY

1. Southeast corner of NE¼ NW¼ Sec. 13,T.2 N., R.5 W. Ground elevation, 1,660 feet (a); depth to water, 60 feet, mud fluid level.

	Thickness (feet)	Depth (feet)
TOP SOIL, dark brown	2	2
CLAY, silty, yellow (Peorian)	4	6
CLAY, soapy, yellow and green, iron-stained	5	11
CLAY, very loose, brown (Loveland old soil?)	6	17
CLAY, sticky, light flesh-colored; more sandy near base (Loveland loess)	42	59
SAND and fine gravel (25% fine gravel)	3	62
GRAVEL, fine to medium to coarse	5	67
CLAY, sandy, yellow	2	69
GRAVEL, coarse; some sand	8	77
CLAY, (no sample obtained)	1	78
GRAVEL, coarse to fine; some sand	7	95
GRAVEL, extremely coarse; some intermixed sand	37	132
SHALE, dark gray (Carlile)	1	133

2. SW¼ SW¼ Sec. 23,T.2 N.,R.5 W.; 50 yards north of the south line. Ground elevation, 1,668 feet (a); depth to water, 123 feet.

	Thickness (feet)	Depth (feet)
SOIL and subsoil, dark brown	4	4
CLAY, silty, yellow (Peorian)	9	13
CLAY, dark brown (Loveland old soil)	4	17
CLAY, silty, flesh-colored (Loveland)	53	70
GRAVEL, well-sorted, small	17	87
GRAVEL, fine to coarse	29	116
GRAVEL, fine; drilled like coarse gravel	10	126
CLAY, sandy, light flesh-colored (Fullerton?)	15	141
SHALE, black (Carlile)	7	148

Note: Lost water in Loveland soil zone.

3. SE¼ SW¼ Sec. 5,T.1 N.,R.5 W.; located about 160 yards north of road and 160 yards west of half-mile line. Ground elevation, 1,698 feet (a); depth to water, 96.55 feet.

	Thickness (feet)	Depth (feet)
SOIL, dark brown	4	4
CLAY, silty yellow (Peorian)	9	13
CLAY, dark brown (Loveland old soil)	4	17
CLAY, silty flesh-colored (Loveland)	58	75
CLAY, sandy, silty, light gray	8	83
GRAVEL, medium	8	91
GRAVEL, medium coarse; some sand	5	96
GRAVEL, medium and very coarse; well-sorted	7	103
SHALE, soft, black (Carlile)	3	106

4. NW¼ NW¼ Sec. 19,T.1 N.,R.5 W.; located in the northeast corner, 0.25 mile east of the northwest corner and about 100 yards south of road. Ground elevation, 1,690 feet (a); depth to water, caved at 74 feet.

	Thickness (feet)	Depth (feet)
SOIL, dark brown	6	6
CLAY, silty, yellow (Peorian)	5	11
CLAY, dark brown (Loveland soil)	3	14
CLAY, silty, flesh-colored; pieces of white concretions (Loveland)	44	58
CLAY, more gray in color than above and more silty (Loveland?)	22	80
CLAY, sandy, yellow to green; particles of gravel	3	83
GRAVEL, fine, and sand; drills very coarse from 85 to 90 feet	12	95
SHALE, black (Carlile)	5	100

5. Southwest corner of Sec. 31,T.1 N.,R.5 W.; located on east side of road, 0.5 mile south and 0.15 mile west of Hardy. Ground elevation, 1,518 feet (a); depth to water, not measured.

	Thickness (feet)	Depth (feet)
ROAD FILL	3	3
SAND, fine	7	10
GRAVEL, medium, (good gravel); thin seam of black clay at 12 feet; water-worn chalk and shale; coarser from 15 to 19 feet	9	19
SHALE, blue black (Carlile)	2	21

6. NE¼ NE¼ Sec. 32, T.1 N.,R.6 W.; located on George Carter farm 3 miles east of Superior, approximately 200 feet northeast of house and about 0.1 mile west of the northeast corner of Sec. 32. Ground elevation, 1,566 feet (a); depth to water, caved at 33 feet, August 8, 1939.

	Thickness (feet)	Depth (feet)
SOIL, black	4	4
CLAY, sticky, yellow; some silt	17	21
CLAY, dark brown	6	27
GRAVEL, fine, and sand	6	33
GRAVEL, medium, very well-sorted, almost no fine material	9	42
SHALE, very sticky and rubbery, dark blue black (Carlile)	2	44

7. NW¼ SW¼ Sec. 33,T.1 N.,R.6 W.; east side of road, 100 feet south of railroad tracks. Ground elevation, 1,534 feet (a); depth to water, not measured.

	Thickness (feet)	Depth (feet)
SOIL	2	2
SAND, clayey	2	4
SAND, coarse	3	7
GRAVEL, medium (good)	4	11
SHALE, blue black (Carlile)	4	15

(t) Elevations estimated from topographic map.
(a) Elevations obtained by altimeter levels.
(i) Elevations established by instrumental levels.

8. Northwest corner of Sec. 35,T.1 N.,R.6 W.; about 100 yards northeast of house on the Stenson farm. Ground elevation, 1,551 feet (a); depth to water, caved at 22.5 feet, August 11, 1939.

	Thickness (feet)	Depth (feet)
SOIL	3	3
CLAY, buff	7	10
CLAY, buff to greenish, iron-stained	11	21
SAND, clayey, gray; silt	3	24
SAND	2	26
GRAVEL, fine to medium at top; size increases downward, coarse at bottom (good gravel)	12	38
SHALE, blue black (Carlile)	4	42

9. Southwest corner of NW¼ SE¼ Sec. 35,T.1 N., R.6 W.; 0.05 mile east of half-mile line on the Joe Gillilan farm. Ground elevation, 1,537 feet (a); depth to water, 16.5 feet, August 11, 1939.

SAND	3	3
SAND, clayey	7	10
SAND, fine	11	21
SAND, coarse; fine gravel	6	27
SHALE, blue black (Carlile)	2	29

10. NW¼ NE¼ Sec. 36,T.1 N.,R.6W.; center of east edge, on the Gillilan farm. Ground elevation, 1,560 feet; depth to water, 29.5 feet, August 11, 1939.

SOIL	4	4
CLAY, brown	6	10
CLAY, silty, buff	8	18
CLAY, silty, iron-stained; small iron concretions	7	25
CLAY, brownish gray; containing gravel	9	34
CLAY, light gray	4	38
SAND and gravel (?) (no sample)	2	40
GRAVEL, medium to coarse, rusty	5	45
GRAVEL, medium	7	52
SHALE, blue black (Carlile)	9	61

11. Southwest corner Sec. 19,T.1 N.,R.7 W.; southeast of Bostwick, on north side of road, 200 feet east of southwest corner. Ground elevation, 1,583 feet (t); depth to water, 6.5 feet, July 14, 1939.

SOIL and road fill	5	5
SAND, silty, light gray brown	2	7
SAND, coarse, some fine gravel	3	10
GRAVEL and sand, medium	10	20
GRAVEL, coarse, some water-worn shale	6	26
SHALE, black (Carlile)	4	30

12. Southwest corner of Sec. 21,T.1 N.,R.7 W.; 0.5 mile north and 2.5 miles west of Superior, 100 yards north of southwest corner. Ground elevation, 1,595 feet (a); depth to water, not measured.

SOIL	3	3
CLAY, slightly silty, light yellow-	8	11
CLAY, silty, dark brown	4	16
GRAVEL, medium, well-sorted; mixed with dark brown silty clay	2	18
SAND and gravel, fine; small percent of medium and coarse gravel	15	33
GRAVEL, medium to fine, some fine sand	6	39
SHALE, very sticky, not indurated, dark blue black (Carlile)	2	41

13. Southeast corner of SW¼ Sec. 29,T.1 N.,R. 7 W.; 0.47 mile east of southwest corner of section on north side of road. Ground elevation, 1,755 feet (t); depth to water 4.6 feet, July 13, 1939.

SAND	5	5
SAND, clayey, fine	3	8
SAND and gravel, fine	4	12
SAND, coarse, and gravel, fine	5	17
SAND and gravel; gravel much coarser than above	5	22
SAND, coarse and gravel, fine; some coarse gravel from 22 to 26 feet; water-worn shale 26 feet down	26	38
SHALE, black (Carlile)	4	42

14. Southeast corner of Sec. 32,T.1 N.,R.7 W.; 240 feet north of south section line, west side of road, 3 miles west and 1 mile south of Superior. Ground elevation, 1,585 feet (t); depth to water, caved at 19 feet, July 17, 1939.

SAND, clayey, buff, (loess-like)	10	10
SAND, fine, buff; less clay than above; mixes with mud	11	21
SAND, medium	3	24
GRAVEL, fine	3	27
SHALE, black (Carlile)	4	31

15. Southwest corner of Sec. 33,T.1 N.,R.7 W.; 0.2 mile north on east side of road, 3 miles west and 0.8 mile south of Superior. Ground elevation, 1,575 feet (t); depth to water, 11.5 feet, July 20, 1939.

SOIL	2	2
SAND, clayey, buff (loess-like)	15	17
SAND, coarse and gravel, fine	6	23
GRAVEL and sand, gravel, medium; coarse lenses; contains much water-worn shale, etc. from 28 feet down	8	31
SHALE, black (Carlile)	6	37

16. Northwest corner of Sec. 10,T.2 N.,R.8 W.; in ditch 75 feet east of the center of road intersection, one mile south of Mt. Clare. Ground elevation, 1,845 feet (a); depth to water, hole filled in.

SOIL, gray brown; claypan	4	4
CLAY, silty, yellow to brown; some iron concretions	11	15
CLAY, brown (Loveland soil)	4	19
CLAY, flesh-colored (Loveland)	10	29
CLAY, more silty than above	4	33

	Thickness (feet)	Depth (feet)
CLAY, silty, yellowish; mixed with gravel and small pieces of dark gray shale	22	55
CHALK, calcareous, white	5	60

17. NW¼ SW¼ Sec. 13,T.2 N.,R.8 W.; 0.4 mile north of southwest corner, in the Arthur Dillon farmyard, 20 feet northeast of the old well. Ground elevation, 1,796 feet (a); depth to water, 69 feet.

SOIL, dark brown	6	6
CLAY, silty, yellow (Peorian)	9	15
CLAY, dark brown (Loveland soil)	3	18
CLAY, flesh-colored (Loveland)	18	36
CLAY, silty, flesh-colored; contains concretion; hard-drilling concretionary zones at 36 and 38 feet	10	46
CLAY, silty, greenish to grayish, small gravel	8	54
GRAVEL, fine to medium	9	63
GRAVEL AND SAND, coarser than above	5	68
CHALK, yellow, grades into grayish blue shale (Niobrara)	2	70

18. Southwest corner Sec. 29,T.2 N.,R.8 W. Ground elevation, 1,681 feet (a); depth to water, caved at 7 feet.

SOIL, dark almost black	12	12
CLAY, silty, flesh-colored (Loveland)	2	14
GRAVEL, fine to medium; grains of each grade size well-sorted	9	23
GRAVEL, medium to coarse	24	47
SHALE, calcareous, dark gray	5	52

19. Northeast corner of SE¼ SE¼ Sec. 1;T.1 N., R. 8 W.; 0.2 mile north of southeast corner. Ground elevation, 1,717 feet (a); depth to water, 26.4 feet.

SOIL, dark brown	2	2
CLAY, silty, yellow (Peorian)	5	7
CLAY, dark brown (Loveland soil)	2	9
CLAY, brownish yellow (Loveland)	4	13
CLAY, somewhat sandy, light brown (Loveland)	3	16
GRAVEL, fine to medium; some sand	2	18
GRAVEL, medium; about 30 percent fine sand	2	20
SAND, coarse, to fine gravel	1	21
GRAVEL, medium and coarse, mostly medium	23	44
SHALE, dark bluish gray; contains white calcareous spots	4	48

20. SE¼ SE¼ Sec. 5,T.1 N.,R.8 W.; center of south edge, 100 yards west of Beaver Creek bridge on north side of road. Ground elevation, 1,635 feet (a); depth to water, not measured.

ROAD FILL	3	3
CLAY, brownish gray	7	10
GRAVEL, coarse	2	12
CHALK, white	1	13
SHALE, calcareous, blue gray; very light gray at 15 feet (Niobrara)	3	16

21. Northeast corner of Sec. 10,T.1 N.,R.8 W.; 300 feet south of northeast corner. Ground elevation, 1,660 feet (a); depth to water, 13.8 feet, August 2, 1939.

LOESS, buff	13	13
LOESS, buff; sandier than above; a little gravel in last few feet	6	19
GRAVEL	3	22
CLAY, limy, yellowish	1	23
CHALK, white	1	24
CHALK, light blue gray	5	29
CHALK, white, some dark gray material at 33 feet (thin seam); darker gray at 36 feet; softer and drilled easier from 45 to 50 feet	21	50
SHALE, black (Carlile)	4	54

22. Northeast corner of Sec. 15, T.1 N.,R.8 W.; 80 feet south of road intersection, west side of road. Ground elevation, 1,634 feet (a); depth to water, 30.3 feet, July 20, 1939 (may still be affected by mud).

SOIL AND CLAY, containing sand and gravel	6	6
SAND, clayey, much coarse gravel	13	19
GRAVEL, coarse, and sand; contains thin clay bands at 45 and 47½ feet; probably contains some cementing material	36	55
SHALE, black (Carlile)	3	58

23. Southeast corner of SE¼ NE¼ Sec. 15,T.1 N., R.8 W.; 0.05 mile north of railroad tracks, west side of road. Ground elevation, 1,620 feet (a); depth to water, 19 feet, July 8, 1939.

ROAD FILL	4	4
CLAY, sandy, buff	11	15
CLAY, silty, sticky, brownish gray; cuts in slabs	19	34
SAND, clayey, gray	1	35
GRAVEL, fine to medium, seems to carry a little clay	4	39
GRAVEL, coarse	2	41
SHALE, black	4	45

24. Southeast corner of NE¼ SE¼ Sec. 15,T.1 N., R.8 W.; 0.28 mile north of southeast corner of section, on west side of road. Ground elevation, 1,611 feet (a); depth to water, 13.6 feet, July 7, 1939.

SOIL and road fill	4	4
SAND, clayey (loess-like material)	2	6
CLAY, silty, buff	17	23
SAND, fine	5	28
GRAVEL, medium to coarse; good gravel	7	35
SHALE, black (Carlile)	14	49

25. Northwest corner of Sec. 17,T.1 N.,R.8 W.; in road intersection. Ground elevation, 1,611 feet (a); depth to water, 6 feet, July 19, 1939.

	Thickness (feet)	Depth (feet)
SOIL, and sand, fine	4	4
SAND, silty, gray	3	7
GRAVEL, fine, and sand, coarse	8	15
SAND, coarse; contains fine gravel	5	20
GRAVEL, fine, clean, greenish	3	23
SHALE, black	4	27

26. Northeast corner of SE¼ NE¼ Sec. 17,T.1 N., R.8 W.; 0.3 mile south of northeast corner of section, on the E. F. Schramm farm. Ground elevation, 1,601 feet (a); depth to water, not measured (caved).

SOIL	4	4
SAND, fine, silty, gray	2	6
SAND, coarse	4	10
GRAVEL, fine; some fine sand	6	16
GRAVEL, fine; coarser than above; has water-worn shale, chalk	5	21
SHALE, dark gray to black (Carlile)	2	23

27. Northeast corner of SE¼ SW¼ Sec. 20,T.1 N., R.8 W. Ground elevation, 1,645 feet (a); depth to water, dry.

SOIL, black	5	5
SILT, clayey, sticky, yellow; came up around drill pipe in collars	15	20
CLAY, yellow; winds up around drill pipe	10	30
CLAY, silty, green, iron-stained	10	40
SAND and fine gravel; drills easy; contains some pieces of light blue clay and Niobrara material	7	47
SHALE, blue black (Carlile)	5	52

28. Southeast corner of Sec. 22,T.1 N.,R.8 W.; 350 feet west of southeast corner, north edge of road. Ground elevation, 1,591 feet (t); depth to water, 6.9 feet, July 12, 1939.

SOIL, and road fill	5	5
SAND, clayey, fine	2	7
SAND, fine to medium grained	10	17
GRAVEL, fine, well-sorted	13	30
GRAVEL, coarser than above, lighter colored, good	8	38
SHALE, dark gray to black	7	45

29. Northwest corner of Sec. 23,T.1 N.,R.8 W.; 0.75 mile west of Bostwick, 60 feet south of section corner, east side of road. Ground elevation, 1,600 feet (t); depth to water, caved at 12 feet, July 10, 1939.

ROAD FILL	3	3
CLAY, sandy, buff	7	10
SAND, contains some clay (darker than above)	5	15
SAND AND GRAVEL, fine; mostly sand- GRAVEL, medium to coarse, light greenish blue, some white, etc.	10	25
	3	28
SHALE, black	5	33

30. Northwest corner of SW¼ NW¼ Sec. 23,T.1 N., R.8 W.; .05 mile south of river bridge. Ground elevation, 1,593 feet (a); depth to water, 6.8 feet, July 11, 1939.

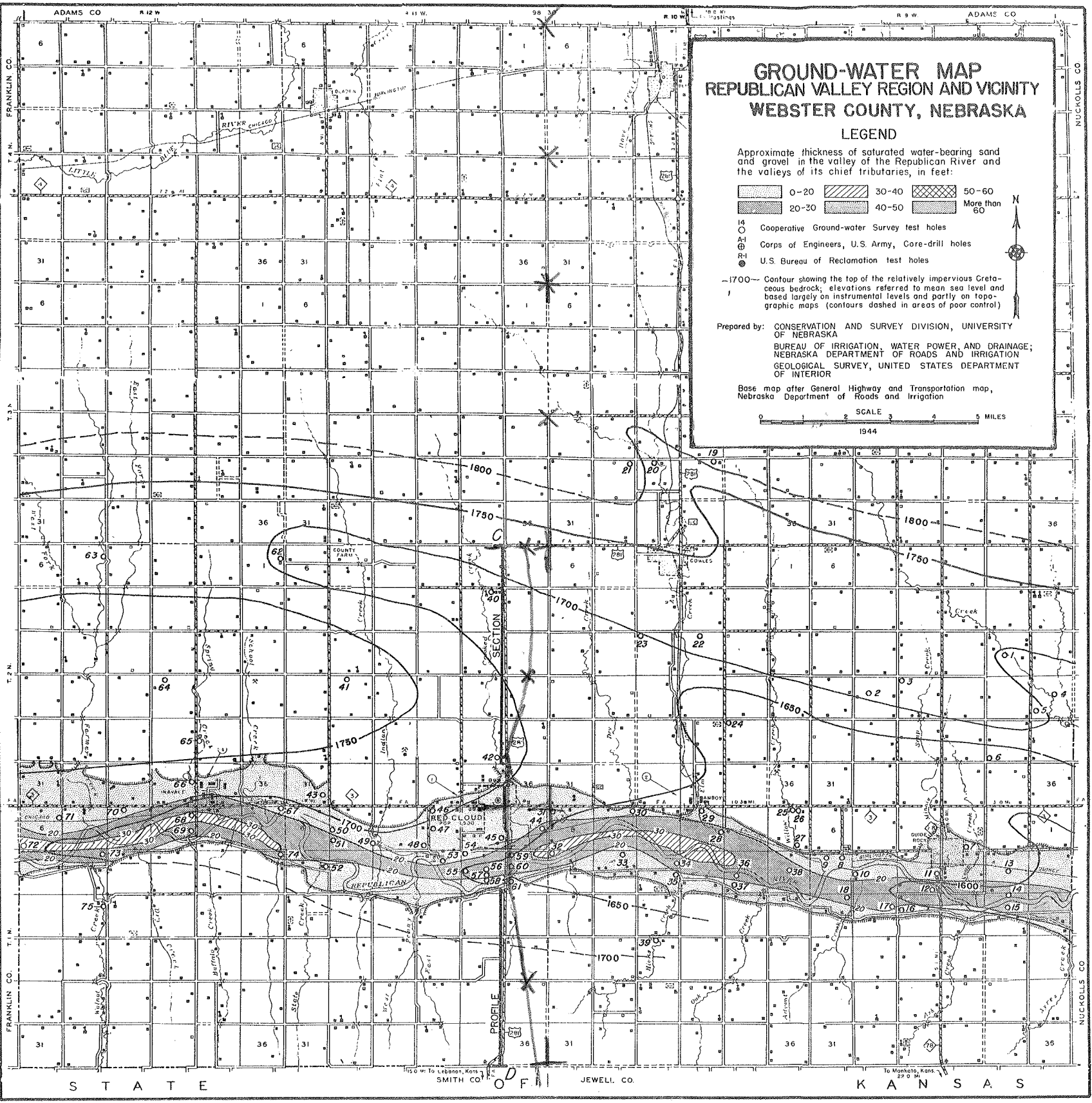
ROAD FILL	3	3
CLAY, sandy	5	8
SAND, fine; some fine gravel	3	11
GRAVEL, and sand, fine	11	22
GRAVEL, coarse	2	24
SHALE, rubbery, sticky, dark gray to black (Carlile)	6	30

31. Northwest corner of NW¼ SW¼ Sec. 23,T.1 N., R.8 W.; 0.32 mile south of bridge over Republican River, 0.53 mile south of north line of section 23, in east ditch. Ground elevation, 1,591 feet; depth to water, 3 feet, July 13, 1939.

SAND; contains some gravel and clayey sand (fill)	5	5
SAND, coarse and very fine gravel	10	15
GRAVEL, fine	8	23
GRAVEL, coarser than above; carries water-worn shale from 25 feet down	5	28
SHALE, dark gray to black (Carlile)	3	31

32. SW¼ NW¼ Sec. 26, T.1 N.,R.8 W.; approximately in center, 1 mile south of river bridge, 0.1 mile east on south side of road. Ground elevation, 1,603 feet (a); depth to water, caved at 14 feet, July 11, 1939.

CHALK, water-worn; reworked Niobrara	5	5
SAND, clayey, brown	14	19
SAND, coarse, and fine gravel	12	31
GRAVEL, fine to medium (good gravel); contains coarse sand	10	41
SHALE, dark gray to black; hard to get sample because gravel and sand caving from above	9	50
SHALE, black, good sample	2	52


GROUND-WATER MAP
REPUBLICAN VALLEY REGION AND VICINITY
WEBSTER COUNTY, NEBRASKA
LEGEND
Approximate thickness of saturated water-bearing sand and gravel in the valley of the Republican River and the valleys of its chief tributaries, in feet:
0-20
20-30
30-40
40-50
50-60
More than 60
Cooperative Ground-water Survey test holes
Corps of Engineers, U.S. Army, Core-drill holes
U.S. Bureau of Reclamation test holes
Contour showing the top of the relatively impervious Cretaceous bedrock; elevations referred to mean sea level and based largely on instrumental levels and partly on topographic maps (contours dashed in areas of poor control)
Prepared by: CONSERVATION AND SURVEY DIVISION, UNIVERSITY OF NEBRASKA
BUREAU OF IRRIGATION, WATER POWER, AND DRAINAGE; NEBRASKA DEPARTMENT OF ROADS AND IRRIGATION
GEOLOGICAL SURVEY, UNITED STATES DEPARTMENT OF INTERIOR
Base map after General Highway and Transportation map, Nebraska Department of Roads and Irrigation
SCALE
0 1 2 3 4 5 MILES
1944
ADAMS CO
FRANKLIN CO.
NUCKOLLS CO
JEWELL CO.
SMITH CO
RED CLOUD
BLUE
LITTLE
REPUBLICAN
COUNTY FARM
COWLES
GUIDE ROCK
BAMBOY
PROFILE
SECTION
STATE OF KANSAS

GROUND-WATER CONDITIONS IN WEBSTER COUNTY

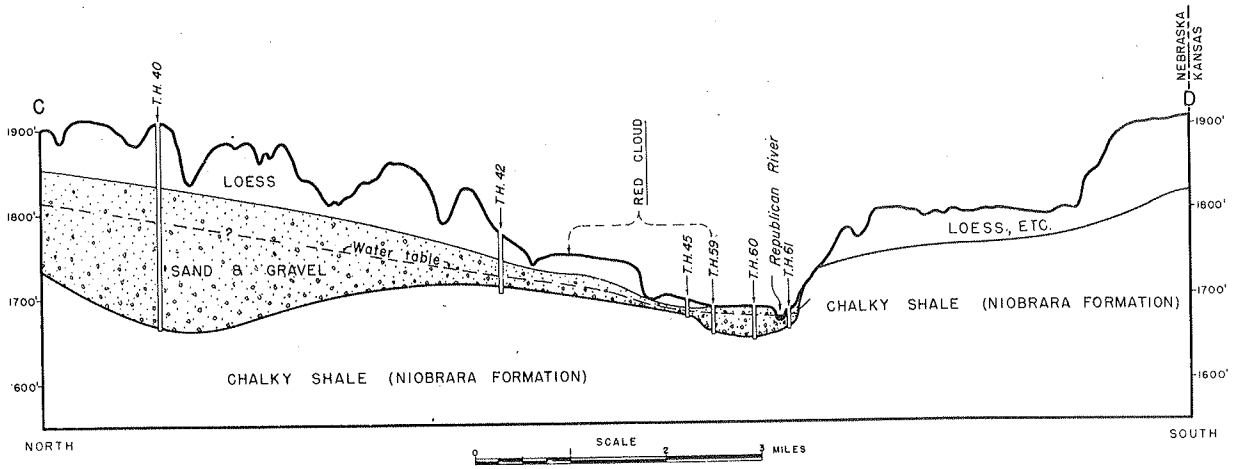
The test-drilling program in Webster County was confined to the southern two-thirds of the County. Here, as in Nuckolls County to the east, the region tested by drilling is separated into three ground-water regions: (1) the area north of the Republican Valley, (2) the Republican Valley region including both the bottomland and terraceland portions of the Valley, and (3) the area south of the Republican Valley.

Although the area north of the Republican Valley in Webster County (See Ground-Water Map of Webster County) is the westward extension of the region north of the Valley in Nuckolls County, it differs from the Nuckolls County region in several important respects. The relatively shallow and high bedrock overlain by thin sand and gravel, which is the predominant feature of this region in Nuckolls County, is much less pronounced in Webster County where test drilling has shown the presence of an important buried channel entering Webster County from the west at a point about 12 miles north of the Kansas-Nebraska line. This buried channel trends eastward for a distance of approximately 6 miles and then trends east-southeastward, joining the Republican Valley region near the east border of Webster County. There is also some evidence of a smaller subsidiary channel that passes southeastward from a point two miles north of Cowles, crosses the Webster-Nuckolls county line about 8½ miles north of the Nebraska-Kansas line, and joins the Republican Valley region near Bostwick in Nuckolls County. Within these buried channels the bedrock is relatively deep and low and is overlain by comparatively thick deposits of sand and gravel, thus differing from the interchannel ridges where the bedrock is high and near the surface and the water-filled sand and gravel is relatively thin. In the course of drilling in the southwest part of this general region, a prominent buried ridge was located, the crest of which extends eastward and eastsouthward from a point about 9 miles north of the Nebraska-Kansas line at the west edge of Webster County to a point three-fourths mile north of Amboy. The buried channels, as described above, are relatively favorable for the development of ground-water supplies and conversely the inter-channel buried ridges are comparatively unfavorable. However, because the sand and gravel deposits north of the Republican Valley are capped by a thick mantle of silty clay (loess) except in places where streams tributary to the Republican have cut through the loess cap, the possibilities of recharge of ground water from local precipitation are greatly restricted and there is more danger of over-development of ground water than in the area of more favorable infiltration along the Republican Valley.

The Republican Valley has an average width of about two miles extending across the County in an east-west direction. Within this region is a buried channel with relatively low bedrock overlain by comparatively thick water-bearing sand and gravel. The deepest part of this channel is located, generally, in the southern part of the Valley. Approximate thicknesses of saturated water-bearing sand and gravel in this region are shown on the Ground-Water Map of Webster County by means of shaded patterns. This area is comparatively favorable for ground-water recharge from local precipitation and stream flow because the clay cap above the more permeable sands and gravels is in many palces either relatively thin or absent. Moreover, the water table (top of water-saturated zone) is closer to the land surface here than in the upland regions outside of the Valley.

The region south of the Republican Valley is coextensive with the region south of the Valley in Nuckolls County and very similar from a ground-water standpoint. This region is characterized by relatively high chalky shale bedrock of the Niobrara formation (Cretaceous), overlain by comparatively thin sands and gravels, capped by loess. It is a poor infiltration area and the more permeable materials occur high above the Republican Valley level and are highly susceptible to ground-water loss by natural discharge from springs along the Valley sides.

The general conditions in these three ground-water regions of Webster County are shown in the following profile section:



Geologic Profile Section C-D. This section is located one-half mile east of Red Cloud and extends in a north-side direction from a point 12 miles north of the Nebraska-Kansas line (C) to the Nebraska-Kansas line (D). Note the deep, sand- and gravel-filled channel in the vicinity of test hole 40, the buried ridge near test hole 42, the buried channel and relatively good infiltration area in the southern part of the Republican Valley region and the high chalky shale bedrock south of the Valley. The dashed line, representing the water table (top of the zone of saturated water-bearing material), slopes southward toward the Republican Valley in the region north of the Valley. The chalky shale is relatively impervious and is a part of the Niobrara formation of Cretaceous age.

LOGS OF TEST HOLES DRILLED IN WEBSTER COUNTY BY THE CONSERVATION AND SURVEY DIVISION AND THE FEDERAL GEOLOGICAL SURVEY

1. Northeast corner of SW¼ Sec. 14,T.2 N.,R. 5 W.; on Doctor Reed's farm, 1¼ miles east and 4½ miles north of Guide Rock. Ground elevation, 1,760 feet (t); depth to water, not measured.

	Thickness (feet)	Depth (feet)
LOAM, black	1	1
SOIL, clayey, brownish	2	3
LOESS, clayey, yellowish	9	12
LOESS, clayey, brownish; some sand	4	16
LOESS, clayey, reddish; more sand, coarser	5	21
SAND and gravel	7	28
SAND, some clay cementing material	1	29
SAND and gravel; At 31 feet hit some coarse gravel	37	66
CHALK, limy white; probably Niobrara limestone	1	67
SHALE, bluish black (Carlile); thin layer of white limy material at 67.5 feet	1	68

2. Northeast corner of SW¼ Sec. 20,T.2 N.,R. 9 W.; 0.5 mile north and 0.4 mile east of southwest corner, on J. B. Guy's farm, 3½ miles north and 1½ miles west of Guide Rock. Ground elevation, 1,825 feet (t); depth to water, not measured.

	Thickness (feet)	Depth (feet)
LOAM, black	1	1
SOIL, clayey, yellowish; some streaks of lime	1	2
LOESS, yellowish	9	11
LOESS, clayey, reddish brown	5	16
LOESS, clayey, reddish and yellowish; contains some black loam	2	18
LOESS, sandy, reddish; grades into sand and gravel at 33 feet	15	33
SAND and gravel	12	45
GRAVEL, fine	8	53
GRAVEL, coarse	2	55
GRAVEL, fine, and sand	3	58
SAND, clayey, reddish	1	59
GRAVEL, fine, and sand	63	122
LIMESTONE, hard (Niobrara?)	1	123

3. Southwest corner of NW¼ NW¼ Sec. 21,T.2 N., R.9 W.; 0.2 mile south of northwest corner, 50 yards east of road along north side of hedge. Ground elevation, 1,820 feet (t); depth to water, not measured.

	Thickness (feet)	Depth (feet)
SOIL, dark brown	4	4
CLAY, silty, yellow (Peorian)	15	19
CLAY, brown (Loveland soil)	3	22
CLAY, silty, flesh-colored; some gravel (Loveland)	6	28
GRAVEL	7	35

Note: Hole abandoned at 35 feet.

4. Northwest corner of SE¼ Sec. 24,T.2 N.,R.9 W.; 2½ miles east and 3½ miles north of Guide Rock. Ground elevation, 1,730 feet (t); depth to water, not measured.

	Thickness (feet)	Depth (feet)
LOAM	1	1
SOIL, clayey, yellowish brown	1	3
LOESS, clayey, yellowish	7	10
LOESS, clayey, reddish brown; some sand	3	13
LOESS, sandy, reddish; some gravel	2	15
SAND and gravel, clayey, light bluish	1	16
SAND and gravel	2	18
SAND and gravel	1	19
CLAY, sandy, thin, reddish	1	20
SAND and gravel	23	43
SAND, fine	2	45
SAND and gravel	13	58
SAND, fine	4	62
GRAVEL, coarse	5	67
CHALK, limy, white (Niobrara)	1	68
SHALE, bluish black (Carlile)	2	70

5. Center of SW¼ SW¼ Sec. 24,T.2 N.,R.9 W.; 2 1/8 miles east and 3 1/8 miles north of Guide Rock. Ground elevation, 1,780 feet (t); depth to water, 32.1 feet, October 11, 1934.

	Thickness (feet)	Depth (feet)
LOAM, black	1	1
LOESS, clayey, brownish	5	6
LOAM, clayey, black	2	8
LOESS, clayey, yellowish	14	22
LOESS, clayey, reddish yellow; some sand and a little gravel; content increases at 25½ feet	5	27
SAND and gravel; at 44 feet a little clay and sand	46	73
CHALK, limy; probably Niobrara	2	75
SHALE, bluish black (Carlile)	1	76

6. Southwest corner of Sec. 26,T.2 N.,R.9 W.; 60 feet north of southwest corner, in the ditch. Ground elevation, 1,754 feet (a); depth to water, 85 feet to fluid mud.

	Thickness (feet)	Depth (feet)
SOIL, brown	4	4
CLAY, brownish yellow (Peorian)	6	10
CLAY, silty, greenish gray	5	15
CLAY, dark brown (Loveland soil)	5	20
CLAY, flesh-colored (Loveland)	2	22
GRAVEL, fine to medium to coarse; small percent of sand	78	100
GRAVEL, fine, well sorted with much white water-worn Niobrara chalk	25	125
SHALE, calcareous, dark gray	2	127

(t) Elevations estimated from topographic map.
(a) Elevations obtained by altimeter levels.
(i) Elevations established by instrumental levels.

7. Southwest corner of SE¼ Sec. 3,T.1 N.,R.9 W.; 600 feet north of highway on G. M. Taylor's farm, about ½ mile east of Guide Rock. Ground elevation, 1,675 feet (a); depth to water, not measured.

	Thickness (feet)	Depth (feet)
LOAM, black	1	1
LOESS, clayey, pinkish yellow; some limy streaks	9	10
SAND, very fine	2	12
GRAVEL	2	14
LOESS, clayey	1	15
SAND; so fine none stays on screen	9	24
GRAVEL, fine, greenish	4	28
SHALE, bluish black (Carlile)	6	34

8. Northwest corner of NE¼ NE¼ Sec. 7,T.1 N., R.9 W.; 100 yards south of northwest corner, at State Recreation Grounds, 2 miles west of Guide Rock. Ground elevation, 1,718 feet (a); depth to water, not measured.

SOIL, dark gray	4	4
CLAY, silty, light yellowish (Peorian)	17	21
CLAY, light brown (Loveland soil)	3	24
CLAY, silty, flesh-colored (Loveland)	4	28
CLAY, sandy, gray (Upland)	2	30
GRAVEL, medium, well sorted	12	42
CLAY, calcareous, silty, light gray	24	66
CHALK, water-worn, calcareous, white (Niobrara); concretions and some gravel	2	68
GRAVEL, fine to medium, well sorted, no fines; bottom 2 feet drilled rapidly, therefore fine sand	19	87

9. Northeast corner NW¼ Sec. 7,T.1 N.,R.9 W.; 0.45 miles east of northwest corner, 2½ miles west of Guide Rock. Ground elevation 1,650 feet (t); depth to water, 5.8 feet, July 21, 1939.

CLAY, brown gray	2	2
CLAY, buff	4	6
SILT, muck, greenish black	4	10
SAND, fine; couldn't get good sample as sand went into drill mud	6	16
GRAVEL, fine; seems to be somewhat cemented	4	20
GRAVEL, fine to medium	3	23
CLAY, limy, yellowish	1	24
SHALE, limy, mudstone, dark gray; some gray clay seams (Niobrara)	7	31

10. Center of west side of NW¼ SW¼ Sec. 8,T.1 N., R.9 W. Ground elevation, 1,640 feet (t); depth to water, 12.1 feet, August 3, 1939.

SAND, fine, top 3 feet blow sand, below white and clean	10	10
GRAVEL, medium fine, some fine sand	5	15
GRAVEL, medium coarse; some water-worn Niobrara chalk and shale	2	17
SAND, fine to coarse	5	22
GRAVEL, fine to coarse, well sorted	8	30
SHALE, calcareous, dark gray (Niobrara)	4	34

11. Southeast corner of SE¼ NE¼ Sec. 9, T.1 N., R.9 W.; 150 yards south of railroad track, 50 feet west of center of highway, on north side of street. Ground elevation, 1,642 feet (a); depth to water, 15.5 feet, July 22, 1939.

LOESS, buff	15	15
SAND, fine, clayey; lost water here and unable to obtain good sample	7	22
GRAVEL, fine, coarser from 25 feet down	7	29
SHALE, limy, blue gray (Niobrara)	3	32

12. Southwest corner of SE¼ SE¼ Sec. 9,T.1 N., R.9 W.; 0.2 mile west of southwest corner, 0.25 mile south and 0.2 mile west of river bridge at Guide Rock. Ground elevation, 1,628 feet, depth to water 6 feet, July 25, 1939.

SOIL, sandy	3	3
SAND, silty	5	8
GRAVEL, fine	6	14
GRAVEL, coarser than above	6	20
GRAVEL, medium	5	25
GRAVEL; same as above but with more sand	4	29
GRAVEL, coarse; has much water-worn lime and shale	5	34
LIMESTONE, chalky, thin, white to light bluish gray, shaly seams (Niobrara)	3	37

13. Center of Sec. 11,T.1 N.,R.9 W.; south of railroad track on Mr. Hunter's farm, 1½ miles east and ½ mile south of Guide Rock. Ground elevation, 1,630 feet (a); depth to water, not measured.

LOAM, black	1	1
LOESS, clayey, bluish	5	6
SAND, fine, green	13	19
SHALE, leached, hard, light blue; getting yellowish color at 23 feet from stain (Niobrara)	6	25

14. Northwest corner of NE¼ Sec. 14,T.1 N.,R.9 W.; on J. F. Wilson's farm 1.0 mile south and 1½ miles east of Guide Rock. Ground elevation, 1,625 feet (a); depth to water, not measured.

LOAM	1	1
SAND, very fine	5	6
SAND, fine; contains a little gravel and water-worn Carlile	10	16
CLAY, bluish black	1	17
SAND, coarse, and fine gravel	4	21
CLAY, bluish black; some sand and gravel	2	23
SAND, fine, and gravel, green; gravel came in at 29 feet	12	35
SHALE (Carlile)	3	38

15. Southwest corner of NE¼ Sec. 14,T.1 N.,R. 9 W.; 0.45 mile west of southeast corner, 100 feet north of road. Ground elevation, 1,625 feet (t); depth to water, 10.3 feet, August 3, 1939.

SOIL, black	5	5

	Thickness (feet)	Depth (feet)
CLAY and sand, fine, silty	10	15
GRAVEL, fine; some fine sand	14	29
GRAVEL, fine, well sorted at top; lower medium well sorted; water-worn Niobrara pieces both chalk and shale	5	34
SHALE, very dark blue black; not very indurated but very sticky; bit plugged at 42 feet (Carlile)	8	42

16. SW¼ NW¼ Sec. 16,T.1 N.,R.9 W.; on George Ohmstede's farm, about 1¼ miles south and about 7/8 mile west of Guide Rock. Ground elevation, 1,645 feet (t); depth to water, not measured.

LOAM, black	1	1
LOESS, sandy	11	12
SAND; so fine could get none on screen for sample	6	18
SAND and gravel	7	25
SAND and coarse gravel	4	29
GRAVEL, finer; some pieces of black clay	1	30
SAND, fine, green; lower one foot coarse	4	34
SHALE, light blue (Carlile)	1	35

17. SE¼ NE¼ Sec. 17,T.1 N.,R.9 W.; on Chris Ohmstede's farm 1 3/8 miles south and 1 mile west of Guide Rock. Ground elevation, 1,645 feet (t); depth to water, not measured.

LOAM, black	6	6
SAND, fine; some loess	3	9
SAND, very fine, green; some gravel came in at 16 feet	9	18
GRAVEL, fine, green; some water-worn Carlile shale	4	22
CLAY, black	2	24
SAND and fine gravel; some black clay	6	30
SAND and fine gravel	5	35
CLAY, black; some sand and gravel	3	38
SAND and gravel	2	40
SHALE, light blue (Carlile)	1	41

18. Northeast corner of NE¼ Sec. 18,T.1 N.,R. 9 W.; on west side of road. Ground elevation, 1,641 feet (a); depth to water, 8.8 feet, August 3, 1939.

SAND, fine, one thin seam gravel	13	13
GRAVEL, fine to medium; some fine sand	4	17
CLAY, very fine, colloidal, black; some interbedded gravel	1	18
SAND, very fine; couldn't get good sample	5	23
GRAVEL, quite coarse, well sorted; some large pieces of water-worn calcareous shale	12	35
SHALE, calcareous, dark gray (Niobrara)	3	38

19. Northeast corner of NW¼ NE¼ Sec. 27,T.3 N., R.10 W. Ground elevation, 1,900 (t); depth to water, not measured.

CLAY, compact, consolidated, silty, red (Loveland loess)	28	28
CLAY, sandy, compact, light brown (Upland)	4	32
GRAVEL, extremely coarse; very little sand	58	90
SHALE, compact, tough, chalky, light gray	15	105

20. Northwest corner of NE¼ Sec. 28,T.3 N.,R. 10 W. Ground elevation, 1,820 (t); depth to water not measured.

SOIL, tough, alkaline, black	22	22
GRAVEL, coarse and fine interbedded sand and gravel	23	45
SHALE, compact, very tough, chalky, light gray	25	70

21. Northwest corner of NE¼ NE¼ Sec. 29,T.3 N., R.10 W. Ground elevation, 1,900 feet (t); depth to water, not measured.

SOIL, silty, gray (loess)	10	10
GRAVEL, coarse and fine interbedded sand and gravel	39	49
CLAY, calcareous, silty, whitish yellow	3	52
GRAVEL, coarse and fine interbedded gravel sand	33	85
SHALE, compact, tough, gummy, chalky, light gray	15	100

22. Northwest corner of NE¼ NE¼ NW¼ Sec. 15,T.2 N.,R.10 W. Ground elevation, 1,800 feet (t); depth to water, not measured.

SOIL, silty, light gray	2	2
LOESS, compact, highly consolidated silt, red	9	11
GRAVEL, coarse and fine interbedded sand and gravel; high clay ball content	71	82
SHALE, compact, tough, gummy, chalky, light gray	15	97

23. Northwest corner of NW¼ Sec. 16,T.2 N.,R.10 W. Ground elevation, 1,800 feet (t); depth to water, not measured.

SOIL, sandy, silty, light gray	4	4
GRAVEL, coarse and fine, interbedded sand and gravel; there are many clay balls present in the gravel	84	88
SHALE, compact, tough, gummy, chalky, light gray	17	105

24. Northwest corner of NW¼ Sec. 26,T.2 N.,R. 10 W.; 50 feet south and 150 feet east of corner. Ground elevation, 1,830 feet (a); depth to water, 112 feet to fluid mud.

SOIL, dark grayish brown	4	4
CLAY, silty, light yellow (Peorian)	10	14
CLAY, brown (Loveland)	3	17
CLAY, sand, flesh-colored; some arratic gravels (Loveland)	8	25
GRAVEL, fine to coarse; fine gravel grains are all nearly the same size	10	35

	Thickness (feet)	Depth (feet)
GRAVEL, fine to medium; well sorted	79	114
SAND, fine, silty	6	120
SAND, some fine to medium gravel	37	157
GRAVEL, coarse, well sorted	12	169
CLAY, sandy, buff to amber yellow	3	172
GRAVEL, fine to coarse; mostly fine white quartz gravel	18	190
SHALE, calcareous, dark gray	5	195

25. Center of north edge of NW¼ NE¼ Sec. 1,T.1 N.,R.10 W.; in Willow Creek school yard. Ground elevation, 1,685 feet (t); depth to water, 8.4 feet, August 1, 1939.

SOIL, black	6	6
CLAY, gray and successively blue	16	22
GRAVEL, medium well sorted, some finer mixed in	6	28
SAND, fine; some coarse sand	12	40

Note: Could not add another joint of pipe because caving hole plugged the pipe.

26. Center of north edge of NW¼ NE¼ Sec. 1,T.1 N.,R.10 W.; in Willow Creek school yard, 15 feet northeast of test number 25. Ground elevation, 1,685 feet (t); depth to water, 8.4 feet, August 1, 1939.

SOIL and subsoil	6	6
CLAY, gray; changing to blue	16	22
GRAVEL, some fines mixed in	12	34
SAND, coarse, some fine mixed in	3	37
GRAVEL, fine to medium; mixed with fine sand	9	46
SAND, fine	1	47
GRAVEL, fair; some fine sand	6	53
SHALE, calcareous, white leached rounded particles at first then gray calcareous (Niobrara)	7	60

27. Center of SW¼ SE¼ Sec. 1,T.1 N.,R.10 W.; about 0.15 mile north of bridge over Willow Creek and 3½ miles west of Guide Rock. Ground elevation, 1,661 feet (a); depth to water, 12 feet, July 27, 1939.

SOIL, sandy, brown	4	4
SAND, clayey, buff	3	7
GRAVEL, dry	2	9
SAND, fine, clayey; no sample, took a great deal of water	6	15
GRAVEL, coarse, used a lot of water	10	25
SHALE, limy, gray (Niobrara)	1	26

28. Northeast corner of SE¼ Sec. 3,T.1 N.,R. 10 W.; 3/4 mile east and 0.6 mile south of Amboy school. Ground elevation, 1,657 feet (t); depth to water, 5 feet, August 2, 1939.

SOIL and black clay	6	6
GRAVEL, medium coarse; some fine sand	4	10
SAND, fine; some gravel	5	15
SAND, coarse, and fine sand	7	22
GRAVEL, fine and well sorted	2	24
SHALE, very calcareous, dark gray, speckled white (Niobrara)	5	29

29. Northeast corner of NW¼ Sec. 3,T.1 N.,R. 10 W. Ground elevation, 1,670 feet (t); depth to water, not measured.

SOIL, silty, sandy, black	15	15
GRAVEL, coarse and fine; interbedded sand and gravel	13	28
SHALE, tough, compact, gummy, black; probably Pierre shale	19	47

30. NE¼ NE¼ Sec. 5,T.1 N.,R.10 W.; 200 yards south of Dry Creek bridge on highway, 75 yards west of creek. Ground elevation, 1,672 feet (a); depth to water, 13.5 feet, September 21, 1939.

SOIL, very sandy	3	3
SAND, gravel and water-worn shale	3	6
SAND, fine, slightly clayey	3	9
GRAVEL, medium to coarse, reddish	11	20
GRAVEL, slightly finer than above, mostly gray to green	8	28
SHALE, calcareous, gray (Niobrara)	1	29

31. Southwest corner of NW¼ NW¼ Sec. 6,T.1 N., R.10 W. Ground elevation, 1,680 feet (t); depth to water, 5.4 feet, August 15, 1939.

ROAD FILL and gray clay	6	6
SAND and fine gravel	9	15
SHALE, calcareous, gray (Niobrara)	2	17

32. Northwest corner of NW¼ Sec. 7,T.1 N.,R. 10 W.; 0.1 mile east of corner. Ground elevation, 1,678 feet (t); depth to water, 7.4 feet, August 19, 1939.

ROAD FILL	1	1
SAND, fine	4	5
SAND, clayey, gray	1	6
SAND and fine gravel, contains much water-worn shale and chalk, some coarse gravel	32	38
SHALE, calcareous, gray (Niobrara)	1	39

33. Northeast corner of NW¼ NE¼ Sec. 8,T.1 N., R.10 W.; 0.05 mile south of corner. Ground elevation, 1,670 feet (t); depth to water, 7.4 feet, August 19, 1939.

FILL from flood	2	2
SOIL, old	2	4
SAND, clayey	2	6
GRAVEL, fine, reddish; water-worn chalk and shale	7	13
GRAVEL, fine to medium, green	2	15
GRAVEL, medium to coarse, green	1	16
SHALE, calcareous, gray (Niobrara)	3	19

34. Southeast corner of SE¼ NE¼ Sec. 9,T.1 N., R.10 W.; 0.15 mile north and 75 yards west of southeast corner. Ground elevation, 1,670 feet (t); depth to water, 6 feet, August 19, 1939.

SOIL	1	1
SAND, clayey, brownish gray	11	12
SAND, silty, gray	3	15
GRAVEL, fine	5	20
GRAVEL, medium to coarse; 25 feet to 30 feet water-worn shale, chalk more abundant than from 30 to 35 feet	15	35

	Thickness (feet)	Depth (feet)
SHALE, calcareous, gray (Niobrara)	3	38

35. Northeast corner of SE¼ Sec. 9,T.1 N.,R.10 W.; 0.1 mile south of corner and 60 feet west of road. Ground elevation, 1,669 feet (t); depth to water, 23.1 feet, August 19, 1939.

SOIL	1	1
SAND, clayey, buff; loess, like	19	20
SAND, very fine; unable to get sample	11	31
GRAVEL, fine to medium	10	41
SHALE, calcareous, gray (Niobrara)	2	43

36. Southwest corner of SE¼ NW¼ Sec. 11,T.1 N., R. 10 W.; about 100 feet south of river. Ground elevation, 1,656 feet (t); depth to water, 4.5 feet, August 3, 1939.

SAND	6	6
GRAVEL, fine, much water-worn Niobrara from 6 feet to 10 feet	12	20
GRAVEL, medium	5	25
GRAVEL, fine to medium	9	34
SHALE, calcareous, gray (Niobrara)	4	38

37. Center of SW¼ SW¼ Sec. 11, T.1 N.,R.10 W.; along north side of road 0.22 mile southeast of west section line, 5 miles west and 1 mile south of Guide Rock. Ground elevation, 1,660 feet (t); depth to water, dry.

SOIL, fine, sandy	5	5
SOIL, sandy, dark brown to black	3	8
SAND, fine, clayey, brown	5	13
SILT, gray	3	16
SHALE, calcareous, gray to bluish-gray (Niobrara)	2	18

38. Southeast corner of NW¼ Sec. 12,T. 1 N.,R.10 W. Ground elevation, 1,649 feet (t); depth to water, 6 feet, August 2, 1939.

SOIL, black and very dark brown	2	2
SAND, very fine, mixed with clay	5	7
GRAVEL, medium coarse; some water-worn Niobrara	4	11
GRAVEL, fine; very well sorted	2	13
GRAVEL, medium; water-worn Niobrara	5	18
GRAVEL, coarse and medium mixed; drills like very coarse	7	25
SOFT LAYER, probably a lense of mud; couldn't get sample	1	26
GRAVEL, medium size, fairly well sorted	3	29

39. Northeast corner NW¼ Sec. 21,T.1 N.,R.10 W.; 100 yards southeast of bridge over Hicks creek on Frank S. King farm. Ground elevation, 1,710 feet, (t), depth to water, not measured.

SOIL	1	1
SILT	8	9
SILT, containing water-worn shale and chalk	11	20
SILT, clayey, greenish; lost water, unable to get good sample	19	39

Note: Farmer's well 100 yards south, 37 feet to shale, shale probably 39 or 40 feet.

	Thickness (feet)	Depth (feet)

40. Southwest corner of NE¼ NE¼ Sec. 11,T.2 N., R.11 W.; 0.25 mile west and 0.2 mile south of northeast corner of section, on the Ted Harris farm. Ground elevation, 1,858 feet, (a); depth to water, caved at 14 feet.

SOIL, brown	2	2
CLAY, silty, yellow (Peorian)	4	6
CLAY, dark brown (Loveland soil)	3	9
CLAY, sandy, gravelly, silty (Loveland)	18	27
GRAVEL, fine to very coarse; very poorly sorted	23	50
CLAY, amber yellow; with imbedded sandgrains	3	53
GRAVEL	3	56
DRILLS like clay; couldn't get sample	6	62
GRAVEL, fine to coarse, poorly sorted; drills intermittently coarse and fine	84	146
CLAY, gray to amber yellow; some imbedded sand	7	153
GRAVEL, fine to coarse; some sand	38	191
CHALK, white leached to 192.5 feet, then dark gray calcareous shale	4	195

41. Northeast corner of NE¼ NW¼ Sec. 20,T.2 N., R.11 W.; 50 yards south of the road and 25 yards east of the entrance to the farm house on the north side of the road. Ground elevation, 1,812 feet (a); depth to water, 3.5 feet.

SOIL, allurial, black	3	3
GRAVEL, fine to coarse	2	5
SAND and small gravel	2	7
GRAVEL, fine to medium, no fines	12	19
CHALK, soft, yellow (Niobrara)	11	30

Note: This well is in a valley bottom so the depth to water is not representative of the upland water table.

42. SE¼ SE¼ Sec. 26,T.2 N.,R.11 W.; 150 yards north of section line on edge of creek bank. Ground elevation, 1,742 feet (a); depth to water, 18.1 feet, September 26, 1939.

SOIL, and dark brown clayey sand	10	10
SAND, light gray to buff	3	13
SAND and gravel, partially cemented	7	20
GRAVEL, coarse; reddish clay seam at 25 feet, thin	5	25
GRAVEL, medium	5	30
SHALE, calcareous, gray	8	38

43. Center of north edge of SE¼ SE¼ Sec. 31,T. 2 N.,R.11 W.; about 0.2 mile north of south section line. Ground elevation, 1,742 feet (t); depth to water, caved at 8 feet, September 9, 1939.

SAND	2	2
SHALE, water-worn, and gravel	4	6
GRAVEL, medium, reddish	6	12
SHALE, calcareous, gray (Niobrara)	7	19

44. NE¼ SE¼ Sec. 1,T.1 N.,R.11 W.; on north side of railroad track and just west of road. Ground elevation, 1,682 feet (t); depth to water, 10 feet, August 19, 1939.

	Thickness (feet)	Depth (feet)
SAND, clayey	8	8
GRAVEL, fine; some sand	17	25
SAND and fine gravel; thin clay seam at 25 feet	11	36
SHALE, calcareous, gray (Niobrara)	2	38

Note: No coarse gravel, water-worn shale and chalk throughout sample.

45. Northeast corner of SE¼ SE¼ Sec. 2,T.1 N., R.11 W.; 0.17 mile north of railroad tracks and 150 feet west of highway on south side of street. Ground elevation, 1,691 feet (t); depth to water, 11 feet, August 19, 1939.

	Thickness (feet)	Depth (feet)
SOIL	7	7
SAND, clayey; has limy concretions, buff-colored	5	12
GRAVEL, reddish; contains some clay	4	16
SHALE, calcareous, gray (Niobrara)	2	18

46. Northwest corner of NE¼ NW¼ Sec. 3,T.1 N., R.11 W.; east side of road, 100 feet south of highway. Ground elevation, 1,756 feet (a); depth to water, caved at 10 feet.

	Thickness (feet)	Depth (feet)
ROAD FILL	1	1
CLAY, grayish green	6	7
CLAY, brown; loess-like	7	14
CHALK, yellowish to white (Niobrara)	15	29

47. Southwest corner of SE¼ NW¼ Sec. 3,T.1 N., R.11 W.; 100 feet south of Mill School on east side of road. Ground elevation, 1,727 feet (a); depth to water 28.2 feet, August 19, 1939.

	Thickness (feet)	Depth (feet)
ROAD FILL	2	2
CLAY, sandy, buff (loess)	16	18
CLAY, sandy, grayish brown	6	24
GRAVEL, medium, and sand, reddish; some clay particles	6	30
GRAVEL, cleaner, yellowish brown	8	38
GRAVEL and sand; some clay	1	39
SHALE, calcareous, gray (Niobrara)	2	41

48. SE¼ SW¼ Sec. 3,T.1 N.,R.11 W.; 0.05 mile north of southwest corner on east side of road. Ground elevation, 1,710 feet (t); depth to water, 19.4 feet, August 19, 1939.

	Thickness (feet)	Depth (feet)
ROAD FILL	2	2
CLAY, sandy, buff (loess-like)	5	7
CLAY, sandy, brown; more clay than above	3	10
CLAY, brown; some gravel	1	11
GRAVEL, medium, reddish yellow; uniform size particles	15	26
GRAVEL, medium; some buff-colored clay and shale and calcareous material	1	27
SHALE, calcareous	2	29

49. SW¼ SW¼ Sec. 4,T.1 N.,R.11 W.; 100 yards west of Indian Creek on north edge of road, north of railroad track. Ground elevation, 1,710 feet (a); depth to water, caved at 10.8 feet.

	Thickness (feet)	Depth (feet)
ROAD FILL and buff clayey sand	5	5
GRAVEL, coarse; some blue silty clay	4	9
GRAVEL, fine, and sand, greenish	6	15
GRAVEL, medium, reddish	4	19
SHALE, calcareous, gray (Niobrara)	3	22

50. Southwest corner NW¼ Sec. 5,T.1 N.,R.11 W.; 50 yards south of railroad track on east side of road. Ground elevation, 1,710 feet (t); depth to water, 5.5 feet, August 22, 1939.

	Thickness (feet)	Depth (feet)
ROAD FILL	2	2
SAND, fine; a little coarse mixed in	6	8
GRAVEL, fine, and sand, greenish	7	15
GRAVEL, fine, greenish	7	22
SHALE, calcareous, gray (Niobrara)	2	24

51. Southwest corner of NW¼ SW¼ Sec. 5,T.1 N., R.11 W.; 0.3 mile south of railroad track on east side of road on G. E. Reed's farm. Ground elevation, 1,707 feet (a); depth to water, 8.6 feet, September 9, 1939.

	Thickness (feet)	Depth (feet)
SAND, fine; some clay	6	6
SAND, coarse, reddish	6	12
GRAVEL, fine, and sand, greenish	6	18
GRAVEL, fine, greenish; some coarse material	12	30
SHALE, calcareous, gray (Niobrara)	7	37

52. Southeast corner of NE¼ Sec. 7,T.1 N.,R.11 W.; northwest corner of intersection, in ditch. Ground elevation, 1,724 feet (t); depth to water, caved at 26.7 feet.

	Thickness (feet)	Depth (feet)
SOIL	5	5
SAND, clayey, buff	15	20
SAND, fine, clayey, buff to gray (loess-like)	9	29
GRAVEL, fine to medium, light reddish	11	40
GRAVEL, medium, greenish; water-worn shale	6	46
SHALE, calcareous, gray (Niobrara)	3	49

53. Center of NW¼ NE¼ Sec. 10,T.1 N.,R.11 W.; 100 yards south of house and 50 yards south of road. Ground elevation, 1,691 feet (a); depth to water, 11 feet, August 19, 1939.

	Thickness (feet)	Depth (feet)
SOIL; some fine sand	7	7
GRAVEL, fine, orange; some shale and calcareous material	3	10
GRAVEL, very fine, mixed with fine sand; some water-worn shale, uniform size particles	7	17
GRAVEL, coarse, grayish; some particles of shale	2	19
SHALE, calcareous, gray (Niobrara)	1	20

54. Northwest corner of Sec. 11,T.1 N.,R.11 W.; north edge of road, 100 feet east of section line road that crosses railroad track to north. Ground elevation, 1,690 feet (t); depth to water, 9 feet, August 19, 1939.

	Thickness (feet)	Depth (feet)
ROAD FILL and clayey sand	3	3
GRAVEL, fine, reddish	7	10
SHALE, calcareous, gray (Niobrara)	3	13

55. Center of south edge of SW¼ NW¼ Sec. 11,T.1 N.,R.11 W.; on Crowell farm. Ground elevation, 1,686 feet (a); depth to water, 9.8 feet, August 18, 1939.

GRAVEL, medium and sand	10	10
GRAVEL, greenish	7	17
GRAVEL, medium, greenish	7	24
GRAVEL, assorted, greenish	12	36
MUD seam	1	37
SHALE, calcareous, gray (Niobrara)	2	39

56. NW¼ SW¼ SE¼ Sec. 11,T.1 N.,R.11 W.; on C. E. Crowell's farm, 200 yards south of test number 57. Ground elevation, 1,683 feet (t); depth to water, not measured.

SAND, fine	4	4
GRAVEL, fine to coarse; pieces of Aragonite and shale	7	11
GRAVEL, fine to coarse, mostly quartz and quartzite; less feldspar, more shale particles	17	28
GRAVEL, coarse, mostly quartz and quartzite; much shale; some fossiliferous material	8	36
SHALE, calcareous, dark gray (Niobrara)	1	37

57. SW¼ NW¼ SE¼ Sec. 11,T.1 N.,R.11 W.; 10 feet northeast of the well, on the Cecil Crowell farm, where the Thiem pumping test was conducted. Ground elevation, 1,682 feet (t); depth to water, not measured.

SAND, fine	8	8
SAND to small gravel, mostly small gravel; much feldspar present	8	16
GRAVEL, fine; mostly quartz and green quartzite	2	18
GRAVEL, fine to coarse; some large pieces of water-worn shale, quartz and quartzite predominate	2	20
GRAVEL, fine to coarse, poorly sorted; much water-worn shale; quartz and quartzite predominate	5	25
SAME as above; several pieces of aragonite	5	30
SAME as above; more large pieces of gravel	5	35
SAME as above; very large gravels and pebbles	3	38
SHALE, calcareous, gray	1	39

58. SW¼ SE¼ Sec. 11,T.1 N.,R.11 W.; 150 feet north of river. Ground elevation, 1,680 feet (t); depth to water, 9.3 feet, August 18, 1939.

SAND, very fine	5	5
GRAVEL, fine, reddish; water-worn Niobrara, many fossils present	4	9
SAME as above with thin mud seam or clay ball at 9 feet	1	10
GRAVEL, coarse; mixed with shale and chalk	5	15
GRAVEL, fine, uniform in size, greenish; some shale present	5	25
GRAVEL, coarse; same type as above	6	31
SHALE, calcareous, dark gray (Niobrara)	2	33

59. Northwest corner of NW¼ Sec. 12,T.1 N.,R.11 W. Ground elevation, 1,686 feet (t); depth to water, 7.5 feet, August 18, 1939.

SOIL	1	1
SAND, fine	4	5
SAND and fine gravel, yellow to reddish	5	10
GRAVEL, fine, greenish, water-worn shale and chalk	5	15
GRAVEL, coarser than above, green; much water-worn shale and chalk 15 feet to 25 feet	16	31
SHALE, calcareous, gray (Niobrara)	1	32

60. Southwest corner of NW¼ Sec. 12,T.1 N.,R. 11 W. Ground elevation, 1,685 feet (t); depth to water, 9.5 feet, August 18, 1939.

SAND, very fine, some soil	6	6
SAND and fine gravel	5	11
GRAVEL, medium, bluish to green	4	15
GRAVEL, medium and fine; much water-worn shale and chalk	5	20
GRAVEL, fine and medium, well sorted; some water-worn shale	7	27
GRAVEL, coarse, quite well sorted	5	32
GRAVEL, fine to coarse	4	36
SHALE, calcareous spots, gray (Niobrara)	2	38

61. South edge of NW¼ SW¼ Sec. 12,T.1 N.,R.11 W.; about 0.1 mile east of west section line. Ground elevation, 1,681 feet (t); depth to water, 9.4 feet, August 18, 1939.

SAND, fine	7	7
GRAVEL, medium coarse	1	8
GRAVEL, fine, yellow	3	11
GRAVEL, fine to medium; much quartzite (Ogallala?)	4	15
SAME as above; much more water-worn Niobrara	6	21
SHALE, calcareous, gray (Niobrara)	1	22

62. Southeast corner of SE¼ NE¼ Sec. 1,T.2 N., R.12 W. Ground elevation, 1,894 feet (a); depth to water, caved at 81.5 feet.

SOIL, black to 5 feet, 5 to 8 dark brown	8	8
CLAY, sandy, gravelly, flesh-colored (Loveland)	8	16
GRAVEL, fine, and sand	17	33
GRAVEL, fine to medium	17	50
GRAVEL, fine to coarse	21	71

	Thickness (feet)	Depth (feet)
GRAVEL, medium coarse to very coarse, well sorted	35	106
GRAVEL, very coarse, well sorted	17	123
CLAY, sandy, gray	8	131
GRAVEL, small and coarse, poorly sorted	12	143
GRAVEL, mostly coarse, some fine	54	197
CLAY, sandy, calcareous, grayish; apparently some gravel	4	201
GRAVEL; some Niobrara pieces	2	203
SHALE, gray to green	7	210

63. SE¼ NE¼ Sec. 5,T.2 N.,R.12 W.; 0.35 mile south from northeast corner of section. Ground elevation, 1,900 feet (t); depth to water, 33 feet.

SOIL, alluvial and colluvial, black	10	10
GRAVEL, fine to coarse, poorly sorted; some zones more sandy than others but all poorly sorted	105	115
CLAY, sandy, gray	7	122
GRAVEL, fine to medium, poorly sorted	33	155
GRAVEL, small and well sorted	21	176
SHALE, calcareous, gray (Niobrara)	5	181

64. Center of north half of NE¼ NW¼ Sec. 22,T. 2 N.,R.12 W. Ground elevation, 1,923 feet (a); depth to water, caved at 79 feet.

SOIL, dark	2	2
CLAY, yellowish-brown (Peorian?)	2	4
CLAY, brown (Loveland Soil)	3	7
CLAY, sandy, flesh-colored (Loveland)	25	32
GRAVEL, fine to coarse, poorly sorted; intermittently drills like coarse cobbles	29	61
CLAY, sandy, gray	13	74
GRAVEL, fine to coarse, very poorly sorted	18	92
GRAVEL, mostly fine and white quartz, some coarse	22	114
GRAVEL, fine, mostly clear and white quartz, some feldspathic material	6	120
CLAY, sandy, gray to green (Fullerton)	11	131
SHALE, blue (Niobrara)	4	135

65. SW¼ NW¼ Sec. 26,T.2 N.,R.12 W.; 0.4 mile south of northwest corner of section on east edge of road and 20 feet west of Spring Creek. Ground elevation, 1,804 feet (a); depth to water, 8.5 feet, September 26, 1939.

ROAD FILL and sandy soil	4	4
GRAVEL, coarse, reddish	6	10
SHALE, limy, cream colored	2	12
SHALE, calcareous, gray (Niobrara)	4	16

66. NE¼ SE¼ Sec.34,T.1 N.,R.12 W.; 0.4 mile north of southeast corner of section. Ground elevation, 1,745 feet (t); depth to water, caved at 16 feet.

SOIL	2	2
SAND, clayey, fine, buff	4	6
SOIL, black	2	8
SAND, limy	1	9
GRAVEL and water-worn white chalk	5	14
GRAVEL, medium to coarse, reddish, rusty at 21 feet	9	23
SHALE, calcareous, gray (Niobrara)	3	26

67. NE¼ NE¼ Sec. 1,T.1 N.,R.12 W.; 0.16 mile west of northeast corner of section, 0.07 mile south of highway on H. W. Lambrecht's farm. Ground elevation, 1,716 feet (a); depth to water, 10.6 feet, August 26, 1939.

SOIL	2	2
SAND, fine	5	7
SAND, fine, silty, gray	4	11
GRAVEL, fine; some water-worn shale and chalk	3	14
GRAVEL, medium, some coarse; contains some fines, not as much shale as above, good gravel	11	25
SHALE, calcareous, gray (Niobrara)	2	27

68. NE¼ NE¼ Sec. 3,T.1 N.,R.12 W.; 0.18 mile south of northeast corner on west edge of road. Ground elevation, 1,723 feet (a); depth to water, 7.9 feet, August 26, 1939.

CLAY, gray	6	6
GRAVEL, fine, water-worn shale	4	10
GRAVEL, fine to medium	15	25
GRAVEL, somewhat coarser than above	13	38
SHALE, calcareous, gray (Niobrara)	2	40

69. Southeast corner of NE¼ SE¼ Sec. 3,T.1 N., R.12 W.; 0.6 mile south of highway. Ground elevation, 1,725 feet (t); depth to water, 7.5 feet, August 26, 1939.

ROAD FILL and very fine sand	6	6
GRAVEL, fine, some fine sand reddish color	6	12
GRAVEL, fine to medium, greenish; some fine sand	8	20
GRAVEL, medium, green, some fine	5	25
GRAVEL, fine to medium, green	3	28
SHALE, calcareous, gray (Niobrara)	3	31

70. North edge of NE¼ NW¼ Sec. 4 ,T.1 N.,R.12 W.; on Fred Arnold's farm, 0.6 mile east of Farmers Creek and 25 yards south of highway. Ground elevation, 1,738 feet (a); depth to water, 7.7 feet, August 26, 1939.

SOIL	2	2
CLAY, buff	4	6
SAND, fine, some clay	5	11
GRAVEL and fine sand	3	14
SHALE, calcareous, gray (Niobrara)	3	17

71. SE¼ NE¼ Sec. 6,T.1 N.,R.12 W.; 0.35 mile south of northeast corner of section, 25 feet west of road and 25 feet north of railroad track. Ground elevation, 1,738 feet (t); depth to water, 9.3 feet, September 9, 1939.

SOIL	4	4

	Thickness (feet)	Depth (feet)
SAND, clayey, buff	3	7
SAND, fine, and gravel	4	11
SHALE, calcareous, gray (Niobrara)	8	19

72. Southwest corner of Sec. 6,T.1 N.,R.12 W.; 75 yards north of corner, on east side of road. Ground elevation, 1,744 feet (t); depth to water, 7.7 feet, August 26, 1939.

	Thickness (feet)	Depth (feet)
SOIL, and sand	6	6
GRAVEL, red	4	10
GRAVEL, medium to coarse; contains green water-worn shale and chalk	5	15
GRAVEL, fine, green	7	22
GRAVEL, medium to coarse, greenish; contains very large water-worn pieces shale and chalk	6	28
GRAVEL, fine, greenish	7	35
GRAVEL, medium, greenish	5	40
SHALE, calcareous, gray (Niobrara)	5	45

73. Northeast corner of Sec. 8,T.1 N.,R.12 W.; 50 feet south of corner, at west edge of road. Ground elevation, 1,733 feet (t); depth to water, 5.9 feet, August 26, 1939.

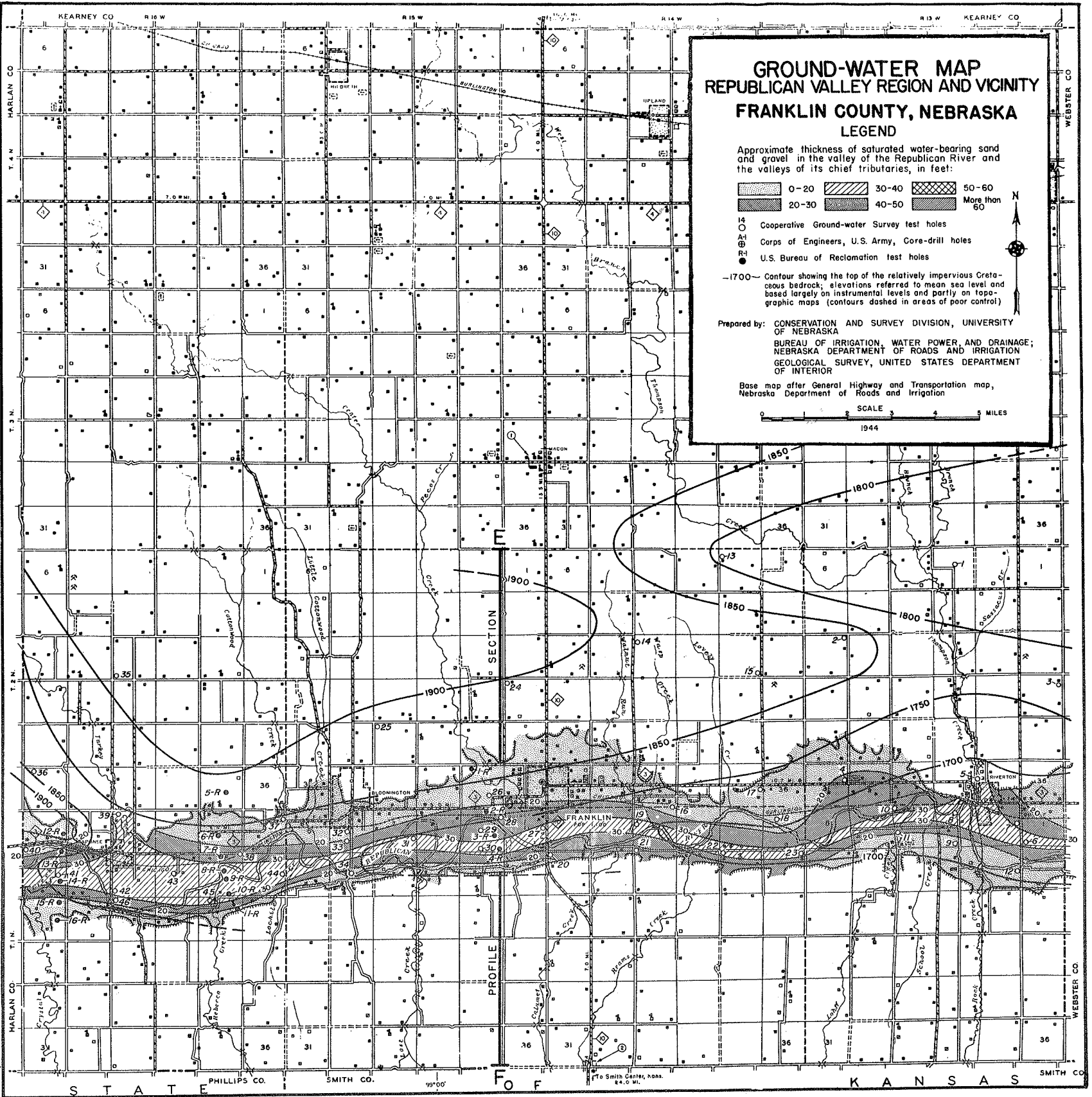
	Thickness (feet)	Depth (feet)
ROAD FILL	2	2
SAND, clayey, fine	3	5
SAND and gravel; many pieces of wood at about 5 feet	5	10
GRAVEL, fine, greenish	6	16
GRAVEL, fine to medium, green; contains large pieces of water-worn shale	4	20
GRAVEL, fine, and sand, coarse	6	26
GRAVEL, fine, greenish	11	37
SHALE, calcareous, gray (Niobrara)	2	39

74. Northeast corner of Sec. 12,T.1 N.,R.12 W.; 150 feet west of the corner, at south edge of road. Ground elevation, 1,715 feet (t); depth to water, 10.2 feet, August 28, 1939.

	Thickness (feet)	Depth (feet)
ROAD FILL	2	2
SAND, clayey, fine, buff	5	7
SAND and gravel, fine	3	10
GRAVEL, medium to coarse	8	18
GRAVEL, medium	7	25
GRAVEL, fine to medium	10	35
GRAVEL, medium	5	40
SHALE, calcareous, gray (Niobrara)	2	42

75. NE¼ NE¼ Sec. 17,T.1 N.,R.12 W.; 150 feet south of Walnut Creek bridge on west side of road. Ground elevation, 1,790 feet (t); depth to water, caved at 25.2 feet.

	Thickness (feet)	Depth (feet)
SAND, clayey, buff; a few fine specks lime	12	12
SAND, fine, clayey, gray brown; limy specks (from Niobrara?)	6	18
SHALE PEBBLES, large, water-worn (Niobrara)	7	25
SAND, fine, clayey, gray; water-worn pebbles of shale and chalk	10	35
SHALE, calcareous, gray (Niobrara)	5	40


GROUND-WATER MAP
REPUBLICAN VALLEY REGION AND VICINITY
FRANKLIN COUNTY, NEBRASKA
LEGEND
Approximate thickness of saturated water-bearing sand and gravel in the valley of the Republican River and the valleys of its chief tributaries, in feet:
0-20
20-30
30-40
40-50
50-60
More than 60
Cooperative Ground-water Survey test holes
Corps of Engineers, U.S. Army, Core-drill holes
U.S. Bureau of Reclamation test holes
—1700— Contour showing the top of the relatively impervious Cretaceous bedrock; elevations referred to mean sea level and based largely on instrumental levels and partly on topographic maps (contours dashed in areas of poor control)
Prepared by: CONSERVATION AND SURVEY DIVISION, UNIVERSITY OF NEBRASKA
BUREAU OF IRRIGATION, WATER POWER, AND DRAINAGE; NEBRASKA DEPARTMENT OF ROADS AND IRRIGATION
GEOLOGICAL SURVEY, UNITED STATES DEPARTMENT OF INTERIOR
Base map after General Highway and Transportation map, Nebraska Department of Roads and Irrigation
SCALE
0 1 2 3 4 5 MILES
1944
N
KEARNEY CO
HARLAN CO
WEBSTER CO
PHILLIPS CO.
SMITH CO.
SMITH CO
R 16 W
R 15 W
R 14 W
R 13 W
T. 4 N.
T. 3 N.
T. 2 N.
T. 1 N.
SECTION
PROFILE
E
F
STATE OF KANSAS
99°00'
To Smith Center, Kans. 24.0 Mi.
UPLAND
MACON
BLOOMINGTON
FRANKLIN
RIVERTON
Republican River
Turkey Creek
Cottonwood Creek
Thompson Creek
Spring Creek
Beaver Creek
Prairie Dog Creek
Deer Creek
Indian Creek
Crystal Creek
Locust Creek
Arbuckle Creek
Coldwater Creek
Rock Creek
Sappa Creek
Prairie Dog Cr.
Driftwood Cr.
Lovell Creek
Cedar Creek
Thompson Cr.
Beaver Cr.
Deer Cr.
Indian Cr.
Crystal Cr.
Locust Cr.
Arbuckle Cr.
Coldwater Cr.
Rock Cr.
Sappa Cr.
Prairie Dog Cr.
Driftwood Cr.
Lovell Cr.
Cedar Cr.
Thompson Cr.
Beaver Cr.
Deer Cr.
Indian Cr.
Crystal Cr.
Locust Cr.
Arbuckle Cr.
Coldwater Cr.
Rock Cr.
Sappa Cr.
1850
1800
1900
1850
1800
1900
1750
1850
1700
1900
1850
1700
1-R
2-R
3-R
4-R
5-R
6-R
7-R
8-R
9-R
10-R
11-R
12-R
13-R
14-R
15-R
16-R

GROUND-WATER CONDITIONS IN FRANKLIN COUNTY

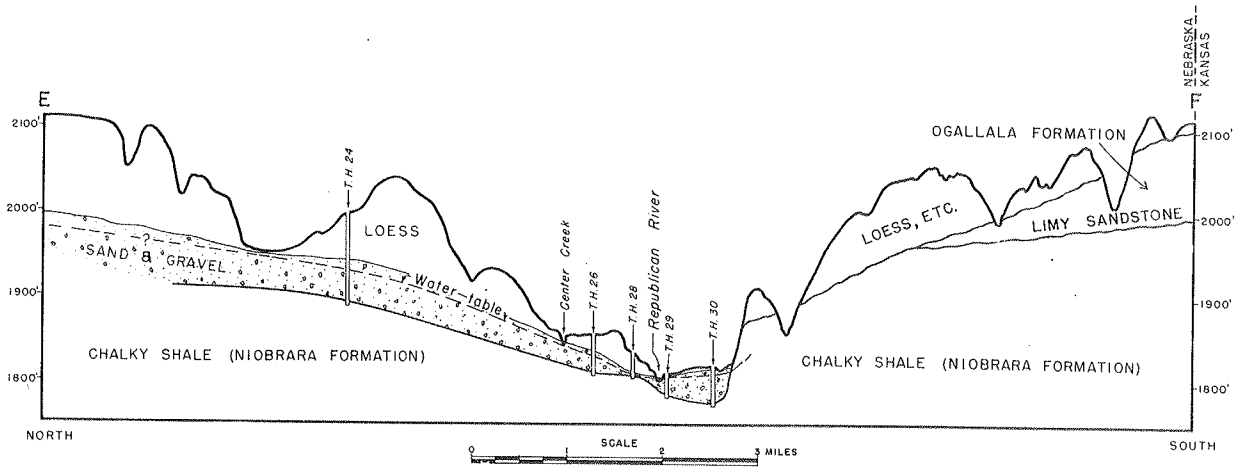
The test-drilling program in Franklin County was confined to the southern half of the County. For the purposes of discussion, the southern half of the county may be separated into three ground-water regions: (1) the area north of the Republican Valley, (2) the Republican Valley including both the bottomland and terraceland of the Valley, and (3) the area south of the Republican Valley.

The area north of the Republican Valley in Franklin County (See Ground-Water Map of Franklin County) is similar in some respects to the eastward extension of the area in Webster and Nuckolls counties. The east-southeastward-trending buried channel, described in the Webster County section of this report, extends into the eastern part of Franklin County. The contours on top of the relatively impervious bedrock (Niobrara formation) show that this buried channel is present at a point about 5 miles north of Franklin and that it extends eastward to a point on the Franklin-Webster county line about 12 miles north of the Nebraska-Kansas state line. That part of the area north of the Republican Valley that lies west of Franklin is characterized by high bedrock overlain by relatively thick deposits of sand and gravel (Geologic Profile Section E-F). However, the buried channel, discovered by drilling farther to the east, may extend into the western part of Franklin County. If present, it would occur north of the area tested by drilling. The bedrock contours also reveal the presence of a rather prominent buried ridge on the north side of the Republican Valley extending eastward from a point near the middle of the west line of Franklin County to a point about 9 miles north of the Nebraska-Kansas state line at the Franklin-Webster county line. This ridge is a westward extension of the buried ridge that is described in the discussion of Webster County. The logs of test holes 2, 3, 14, and 15 which were drilled along this ridge show that relatively thick deposits of sand and gravel were encountered above the bedrock, but it is believed that the most favorable area north of the Republican Valley for developing ground-water supplies is in the vicinity of the buried channel that lies north of the bedrock ridge, north and east of Franklin. The log of test hole 1 shows that the saturated water-bearing deposits between the depths of 68 and 188 feet are principally gravel. In Franklin County, as in Webster and Nuckolls counties to the east, the sand and gravel deposits north of the Republican Valley are capped by a thick mantle of silty clay (loess), except where streams, tributary to the Republican River, have cut through the loess mantle. Recharge to the ground-water reservoir from local precipitation is therefore greatly restricted and possibilities for large developments of ground water are rather limited in comparison with those in more favorable infiltration areas in the Republican Valley.

The Republican Valley extends across the county in an east-west direction and has an average width of about 2 miles. In the vicinity of Franklin the Valley is nearly 3 miles wide. In Franklin County, as in Webster County to the east, a buried bedrock channel containing comparatively thick deposits of water-bearing sand and gravel occurs within this region. In general, the deepest part of this channel is located near the southern limit of the valley. The approximate thicknesses of saturated water-bearing sand and gravel are shown on the Ground-Water Map of Franklin County by means of shaded patterns. In this region the conditions for ground-water recharge from local precipitation and from stream flow are unusually favorable, because the clay cap overlying the more permeable sands and gravels is, in most places, either relatively thin or absent. The water table in the Republican Valley lies at relatively shallow depths below the land surface, whereas it lies at greater depths beneath the upland areas and intermediate slopes bordering the Valley. This region is also situated favorably for intercepting ground water that is moving toward the Valley from beneath the upland areas north of the Valley (see Geologic Profile Section E-F).

The region south of the Republican Valley is similar in character to the region south of the Valley in Webster and Nuckolls counties to the east and is coextensive with it. Ground-water conditions in this region are quite similar in many respects in all three counties. This region is characterized by relatively high chalky shale bedrock (Niobrara formation) which is overlain by comparatively thin sands and gravels capped by loess. The opportunities for infiltration of any precipitation falling on this loess-covered region are poor. The more permeable materials overlying the shale bedrock are subject to natural leakage along the Valley sides by virtue of their relatively high elevations above the Republican Valley.

The general conditions in these three ground-water regions in Franklin County are shown in the following geologic profile section:



Geologic Profile Section E-F. This section is located 1 mile west of the center of the town of Franklin and extends in a north-south direction from a point 12 miles north of the Nebraska-Kansas state line (E) to the Nebraska-Kansas state line (F). Note the increase in thickness of the sand and gravel northward between test holes 26 and 24, the bedrock ridge in the vicinity of test hole 24, the relatively good infiltration area immediately south of the Republican River in the vicinity of test holes 29 and 30, the high chalky shale bedrock (Niobrara formation) south of the Valley, and the relatively thick loess cap both north and south of the Republican Valley. The dashed line representing the water table indicates that the water table slopes southward toward the Republican Valley. The chalky shale is relatively impervious and is a part of the Niobrara formation of Cretaceous age. Variable thicknesses of limy sandstone (Ogallala formation of Tertiary age) occur above the Niobrara formation and below the loess and associated materials in much of the upland south of the Republican River.

LOGS OF TEST HOLES DRILLED IN FRANKLIN COUNTY BY THE CONSERVATION AND SURVEY DIVISION AND THE FEDERAL GEOLOGICAL SURVEY

1. Southeast corner of NW¼ Sec. 3,T.2 N.,R.13 W.; 50 yards west of road corner in north ditch. Ground elevation, 1,927 feet (a); depth to water, 68 feet.

	Thickness (feet)	Depth (feet)
CLAY, sandy, concretionary, buff (Loveland)	10	10
GRAVEL, intermixed with above	24	34
CLAY, sandy, gravelly, gray (Upland)	3	37
GRAVEL, fine to very coarse; very hard drilling	3	40
GRAVEL, mostly fine; more quartz in sample	44	84
GRAVEL, medium to coarse	73	157
CLAY	15	172
GRAVEL, coarse	16	188
NIOBRARA, white	1	189

2. Northeast corner of NE¼ NE¼ Sec. 18,T.2 N., R.13 W.; 60 yards south and 50 yards west of northeast corner. Ground elevation, 2,020 feet (a); depth to water, not measured.

	Thickness (feet)	Depth (feet)
SOIL, dark gray	3	3
CLAY, silty, yellow (Peorian)	13	16
CLAY, dark brown (Loveland)	3	19
CLAY, sandy, silty, flesh-colored (Loveland)	59	78
GRAVEL, fine to coarse, very poorly sorted	36	114
GRAVEL, smaller than above, well sorted	23	137
GRAVEL, smaller than above, well sorted	20	157
CHALK, yellow; then dark gray calcareous shale (Niobrara)	2	159

3. Center of SE¼ SE¼ NE¼ Sec. 24,T.2 N.,R.13 W.; 50 feet west of house. Ground elevation, 1,928 feet (a); depth to water not measured.

	Thickness (feet)	Depth (feet)
SOIL, grayish-brown	2	2
CLAY, silty, yellow (Peorian)	11	13
CLAY, loose, brown (Loveland)	4	17
CLAY, sandy, flesh-colored; becoming more sandy with depth	11	28
CLAY, sandy, light-gray (Upland)	3	31
GRAVEL, fine to coarse, poorly sorted	29	60
GRAVEL, mostly fine to medium	15	75
GRAVEL, coarse quite well sorted although some sand	15	90
CHALK, soft, yellow (Niobrara)	5	95

4. Southeast corner of NE¼ Sec. 31,T.2 N.,R.13W.; 100 feet north of highway, west side of road, across from cemetery. Ground elevation, 1,829 feet (t); depth to water, 44.6 feet, September 21, 1939.

	Thickness (feet)	Depth (feet)
ROAD FILL	3	3
SAND, clayey, buff	10	13
SAND, slightly clayey, reddish brown	3	16
CLAY, fine, sandy, salmon-colored	15	31
SAND, fine, greenish gray; has some clay	9	40
GRAVEL, fine; some clay	10	50
GRAVEL, fine to medium, red	10	60
GRAVEL, medium, some coarse, red	8	68
SHALE, calcareous, gray; light at contact (Niobrara)	1	69

5. SW¼ NW¼ Sec. 35,T.2 N.,R.13 W.; 0.15 mile north of southwest corner on east side of road. Ground elevation, 1,780 feet (a); depth to water, 11.5 feet, September 9, 1939.

	Thickness (feet)	Depth (feet)
SAND, fine, clayey; some soil development	4	4
SAND, clayey, buff; some gravel	3	7
GRAVEL, coarse, reddish	2	9
CLAY, silty, gray; some gravel	4	13
CHALK PEBBLES and silty sand	3	16
SILT, gray-black	11	25
GRAVEL, medium to coarse, varicolored, mostly green and pink to lavender	17	42
SHALE, calcareous, gray (Niobrara)	6	48

6. Southwest corner of Sec. 1,T.1 N.,R.13 W. Ground elevation, 1,752 feet (t); depth to water, 8.4 feet, September 9, 1939.

	Thickness (feet)	Depth (feet)
SAND, fine, buff, cemented	4	4
SAND and fine gravel	4	8
GRAVEL, medium to coarse, greenish; large pieces water-worn shale and lime	15	23
GRAVEL, fine; thin clay seam at 28 feet	7	30
GRAVEL, medium to coarse, greenish	10	40
SHALE, calcareous, gray (Niobrara)	5	45

7. Northeast corner of SE¼, Sec. 2,T.1 N.,R.13 W.; 50 yards north of farm driveway, west side of road. Ground elevation, 1,760 feet (t); depth to water, 15.4 feet, September 9, 1939.

	Thickness (feet)	Depth (feet)
SOIL	4	4
SAND, clayey, dark brown	4	8
SAND, fine, buff	6	14
SAND, fine, gray (No sample)	8	22
GRAVEL, fine, and sand; some water-worn shale	8	30
GRAVEL, fine to medium, greenish	10	40
GRAVEL, medium to coarse	4	44
SHALE, calcareous, gray (Niobrara)	5	49

8. Center west edge of NW¼ NE¼ Sec. 3,T.1 N., R.13 W.; 0.2 mile southwest of river bridge on west side of road. Ground elevation, 1,761 feet (a); depth to water, 11 feet, September 9, 1939.

	Thickness (feet)	Depth (feet)
ROAD FILL and cemented sand	6	6
SAND, coarse, reddish	3	9
GRAVEL, fine, reddish; a few water-worn shale pieces	7	16

(t) Elevations estimated from topographic map.
(a) Elevations obtained by altimeter levels.
(i) Elevations established by instrumental levels.

	Thickness (feet)	Depth (feet)
GRAVEL, fine, greenish; water-worn shale and chalk	6	22
GRAVEL, fine as above; mud seam at 22 feet, also more large pieces water-worn shale	11	33
GRAVEL, fine to medium, greenish; some black gravel, a little water-worn shale	11	44
SHALE, calcareous, gray (Niobrara)	3	47

9. Southeast corner of NE¼ Sec. 3,T.1 N.,R.13 W.; 0.48 mile south of northeast corner, 1 mile south of river bridge on west side of road. Ground elevation, 1,755 feet (a); depth to water, caved at 7.5 feet, September 9, 1939.

ROAD FILL	3	3
SAND, clayey, gray	5	8
GRAVEL, fine, greenish	5	13
SHALE, calcareous, gray	3	16

10. Northwest corner of NW¼ Sec. 4,T.1 N.,R.13 W.; 0.05 mile south of corner, 150 feet south of old house foundation and 80 feet east of section line. Ground elevation, 1,765 feet (a); depth to water, 6 feet, September 9, 1939.

SAND, fine	2	2
SOIL, black, and dark gray clay	8	10
GRAVEL, fine; some sand	8	18
GRAVEL, fine to medium; some pieces dark clay	7	25
GRAVEL, medium, some fines, water-worn shale and lime	7	32
SHALE, calcareous, gray (Niobrara)	5	37

11. Northwest corner of SW¼ Sec. 4,T.1 N.,R.13 W.; 250 feet south of corner on east side of road. Ground elevation, 1,769 feet (t); depth to water, caved at 11 feet, September 9, 1939.

ROAD FILL	3	3
SAND, clayey, buff	6	9
SAND	13	22
GRAVEL, fine, greenish; some sand	8	30
GRAVEL, fine, greenish; less sand than above	10	40
GRAVEL, fine to medium, greenish	5	45
SHALE, calcareous, gray (Niobrara)	3	48

12. Northeast corner of SE¼ Sec. 11,T.1 N.,R. 13 W.; about 150 feet south of river bridge, west side of road. Ground elevation, 1,750 feet (t); depth to water, 8.5 feet, September 9, 1939.

ROAD FILL	7	7
GRAVEL, medium to coarse, reddish; large pieces water-worn shale	5	12
SHALE, calcareous, gray (Niobrara)	2	14

13. Northwest corner of SW¼ NW¼ Sec. 2,T.2 N., R.14 W.; 40 yards south of house and 60 yards east of west section line. Ground elevation, 2,072 feet (a); depth to water, not measured.

SOIL, dark gray	4	4
CLAY, silty, greenish (Peorian)	14	18
CLAY, brown (Loveland)	3	21
CLAY, silty, sandy, gray and flesh-colored; more sand after 35 feet	59	80
CLAY, very sandy, buff; some gravel	16	96
GRAVEL, fine to coarse; very poorly sorted	34	130
GRAVEL, fine to coarse, more fine than coarse; poorly sorted	46	176
GRAVEL, fine; well-sorted	6	182
GRAVEL, fine to coarse; poorly sorted	13	195
CLAY, sandy, light gray (Fullerton)	6	201
GRAVEL, fine and sand	9	210
GRAVEL, fine to coarse; poorly sorted, more quartz coming in, less feldspar; drills very coarse	5	215
SMALL coal-like pieces; drills with difficulty	5	220
GRAVEL, fine to coarse; poorly sorted	2	222
GRAVEL, fine to coarse; more fine than coarse	3	225
GRAVEL, coarse	2	227
GRAVEL, fine to coarse; mostly small, poorly sorted	38	265
GRAVEL, fine to medium, mostly fine; much quartz	10	275
GRAVEL, fine to medium, mostly fine; much quartz	5	280
SHALE, calcareous, dark gray (Niobrara)	2	282

14. Northwest corner of SW¼ NW¼ Sec. 16,T.2 N., R.14 W.; 30 feet south of fence and 10 feet east of road. Ground elevation, 2,060 feet (t); depth to water, caved at 35.5 feet.

SOIL, dark gray	2	2
CLAY, silty, yellow (Peorian)	12	14
CLAY, brown (Loveland)	3	17
CLAY, silty to sandy, flesh-colored; sandy from 25 to 81 feet	64	81
CLAY, green; some gravel and sand	3	84
GRAVEL, coarse to fine and sand; drills very coarse	12	96
GRAVEL, mostly very coarse, some fine; so coarse twisted and ruined bit	31	127
CLAY, sandy, gray to buff (Fullerton)	9	136
GRAVEL, fine to coarse; spent 2 hours going one foot, 143 to 144 feet	8	144
COBBLES, very large; may be blocks or boulders (1½ hours)	3	147
GRAVEL, medium to coarse	6	153
GRAVEL, coarser than above; some fine gravel; more quartz, less feldspar	3	156
GRAVEL, fine to coarse, mostly fine; much quartz, little feldspar	14	170
CHALK, fairly hard, white; then soft yellow, chalk	2	172

15. Northeast corner of NE¼ Sec. 23,T.2 N.,R.14 W.; 50 feet west of center of road on north edge of section. Ground elevation, 2,011 feet (a); depth to water, 97 feet to fluid mud.

SOIL, gray brown	2	2

	Thickness (feet)	Depth (feet)
CLAY, silty, yellow (Peorian)	12	14
CLAY, chocolate brown (Loveland)	3	17
CLAY, silty, flesh-colored (Loveland)	28	45
SAND, fine, gray; cemented with clay	6	51
GRAVEL and sand, fine to medium; poorly sorted	11	62
GRAVEL, medium to coarse in the sample but drills like coarse; well sorted	8	70
CLAY, sandy, gray	2	72
GRAVEL, medium to coarse; drills very coarse	27	99
GRAVEL, medium coarse; well sorted	11	110
GRAVEL, coarse; well sorted	6	116
CHALK, soft, yellow (Niobrara)	5	121

16. Southeast corner of SE¼ Sec. 33,T.2 N.,R. 14 W.; southwest corner of intersection, 8 feet east of fence. Ground elevation, 1,793 feet (t); depth to water, 7.6 feet, September 9, 1939.

SOIL, sandy	2	2
CLAY, sandy, buff	5	7
GRAVEL, fine, some larger material; very easy to drill	17	24
SHALE, calcareous, gray (Niobrara)	5	29

17. NE¼ SE¼ Sec. 35,T.2 N.,R.14 W.; 0.2 mile south of highway and 60 feet east of farm road. Ground elevation, 1,835 feet (t); depth to water, 41.8 feet, September 21, 1939.

SOIL	3	3
CLAY, dark brownish gray	2	5
SAND, silty, buff	8	13
CLAY, dark brown	2	15
SAND, clayey, light brownish gray	16	31
SAND, fine, cemented	5	36
GRAVEL, fine	3	39
GRAVEL, medium, good	12	51
SHALE, calcareous, gray; yellow at contact (Niobrara)	4	55

18. Northwest corner of SE¼ NW¼ Sec. 1,T.1 N., R.14 W.; 75 yards south of railroad tracks. Ground elevation, 1,787 feet (t); depth to water, 14.9 feet, September 21, 1939.

SOIL and fine sand	7	7
GRAVEL, fine, some larger	6	13
GRAVEL, medium; some coarse gravel, mostly red	12	25
SHALE, clacareous, gray (Niobrara)	2	27

19. Southwest corner of NW¼ Sec. 4,T.1 N.,R.14 W.; 0.53 mile south of railroad track, 30 feet east of road. Ground elevation, 1,796 feet (a); depth to water, 8.2 feet, September 9 1939.

SOIL and fine sand	7	7
GRAVEL, fine, reddish	7	14
GRAVEL, fine to medium, some coarse, greenish; water-worn shale	5	19
GRAVEL, fine	6	25
GRAVEL, medium, greenish	10	35
GRAVEL, coarser than above; some soft clay	6	41
SHALE, calcareous, gray (Niobrara)	5	46

20. Northwest corner of Sec. 7,T.1 N.,R. 14 W.; 100 feet southeast of road intersection. Ground elevation, 1,805 feet (t); depth to water, 5.4 feet, September 9, 1939.

SOIL	2	2
GRAVEL, fine, and sand	8	10
GRAVEL, fine to medium; carries quite a quantity of water-worn shale	5	15
GRAVEL, medium, slightly coarser than above; much less water-worn shale	12	27
SHALE, calcareous, gray (Niobrara)	2	29

21. Southwest corner of Sec. 4, T.1 N.,R.14 W., south edge of east and west road, at north end of south road. Ground elevation, 1,801 feet (a); depth to water, 12.7 feet, September 9, 1939.

SAND, clayey, light brown	7	7
SOIL, black	3	10
SAND, clayey, brown	5	15
GRAVEL, fine; large water-worn shale particles	12	27
SHALE, water-worn; chalk with some gravel	8	35
SHALE, calcareous, gray (Niobrara)	4	39

22. Northwest corner of NW¼ Sec. 11,T.1 N.,R.14 W.; 150 feet south of corner on east side of road. Ground elevation, 1,791 feet (t); depth to water, 10.9 feet, September 9, 1939.

ROAD FILL and fine clayey sand	5	5
SAND, fine	4	9
SAND, a little fine gravel, reddish, green at base	6	15
SAND and fine gravel, greenish	8	23
GRAVEL, medium, greenish, water-worn shale, clay, lime	7	30
GRAVEL, fine, greenish	5	35
GRAVEL, medium, some coarse, greenish; some water-worn shale, lime	9	44
SHALE, calcareous, gray (Niobrara)	5	49

23. Northeast corner of NE¼ Sec. 12,T.1 N.,R.14 W.; 100 feet south of corner on west side of road. Ground elevation, 1,779 feet (t); depth to water, 8.3 feet, September 9, 1939.

ROAD FILL	2	2
SAND, clayey, fine, buff	4	4
SAND, coarse, and fine gravel, reddish	5	11
GRAVEL, fine, greenish; water-worn shale and chalk	12	23
CLAY, yellowish gray; some rusty streaks very sticky came up in collar around pipe	5	28
GRAVEL, medium, some fine green predominating	12	40
SHALE, calcareous, gray (Niobrara)	5	45

24. Northwest corner of NW¼ Sec. 24,T.2 N.,R. 15 W.; 0.15 mile south of corner, 8 feet east of east ditch. Ground elevation, 1,973 feet (a); depth to water, 43.5 feet, November 11, 1939.

	Thickness (feet)	Depth (feet)
SOIL-LIKE DEVELOPMENT, dark, almost black; probably terrace deposit	7	7
CLAY, silty, yellow, either terrace or Peorian loess, few small gastropods, drills very rapidly and easily	21	28
CLAY, sandy, dark and light gray; drills easily and contains gastropods and gravel	3	31
GRAVEL, medium to coarse; drills very coarse, some fine gravel and sand	8	39
SAND, clayey, gray	4	43
GRAVEL, medium to coarse; more quartz coming in	15	58
GRAVEL, very coarse to pebbles	2	60
GRAVEL, medium to coarse, much quartz	3	63
GRAVEL, coarse	4	67
GRAVEL, medium to coarse, much quartz	3	70
GRAVEL, mostly coarse, poorly sorted	5	75
GRAVEL, fine to coarse, mostly fine; much white quartz	3	78
GRAVEL, very coarse to pebbles	5	83
CHALK, yellow to almost white (Niobrara)	3	86

25. NW¼ NW¼ Sec. 28, T.2 N.,R.15 W.; 0.15 mile east of northwest corner and 20 feet south of south ditch. Ground elevation, 2,030 feet (t); depth to water, not measured.

SOIL, dark gray	3	3
CLAY, silty, yellow (Peorian)	13	16
CLAY, loose, brown (Loveland)	3	19
CLAY, loose, silty, sandy, flesh-colored (Loveland)	29	48
SAND, fine, some coarser grains, more quartz than average	15	63
CLAY, sandy, buff	6	69
GRAVEL, medium to coarse; quite well sorted, much quartz	12	81
GRAVEL, fine to coarse; mostly fine and medium, much quartz	6	87
GRAVEL, coarse, some finer	12	99
GRAVEL, fine, and sand; each well sorted; much quartz	7	106
GRAVEL, fine; drills with difficulty as if large cobbles	4	110
GRAVEL, mostly fine, well sorted, and sand	33	143
GRAVEL, medium to coarse, some fine; more feldspar, less quartz	4	147
DRILLS like clay; couldn't get sample	2	149
GRAVEL, coarse, well sorted	1	150
CHALK, yellow (Niobrara)	4	154

26. Southeast corner of NW¼ SE¼ Sec. 35,T.2 N., R.15 W.; northwest corner of intersection. Ground elevation, 1,867 feet (a); depth to water, 37.1 feet, September 21, 1939.

SOIL and fine sand	4	4
SAND, slightly clayey, dark brown	3	7
SAND, clayey, buff (loess-like)	17	24
SAND, clayey, dark brown	5	29
SAND	2	31
GRAVEL, fine, reddish	5	36
GRAVEL, medium, reddish	19	55
SHALE, calcareous, gray; rusty colored at contact (Niobrara)	4	59

27. Southeast corner NE¼ Sec. 1,T.1 N.,R.15 W.; 50 yards west of highway, 40 feet north of farm road and 0.5 mile south of railroad track. Ground elevation, 1,814 feet (t); depth to water, 10.5 feet, September 9, 1939.

SOIL and buff-colored clayey sand	10	10
GRAVEL, fine to medium, greenish	10	20
GRAVEL, fine to medium, greenish	10	30
GRAVEL, fine to medium, greenish	10	40
GRAVEL, same as above but more water-worn shale	12	42
SHALE, calcareous, gray (Niobrara)	7	49

28. Center east edge of NE¼ NE¼ Sec. 2,T.1 N., R.15 W.; west side of road, 100 yards south of railroad track. Ground elevation, 1,826 feet (t); depth to water, caved at 10.5 feet, September 9, 1939.

SOIL and brown clayey sand	8	8
CLAY, silty, gray	7	15
SAND and fine gravel	3	18
SHALE, calcareous, gray (Niobrara)	18	22

29. Southeast corner of NW¼ Sec. 2,T.1 N.,R.15 W.; 20 feet west of road and 0.55 mile north of south edge of section. Ground elevation, 1,820 feet, (t); depth to water, 12.7 feet, September 13, 1939.

SOIL, sandy	2	2
SOIL, sandy, black	3	5
SAND, buff	2	7
SAND, water-worn shale, lime, a little fine gravel	3	10
GRAVEL, fine, reddish, a little water-worn chalk	7	17
GRAVEL, medium, some coarse, greenish, water-worn chalk and shale	18	35
SHALE, calcareous, gray (Niobrara)	4	39

30. Southeast corner of SW¼ Sec. 2,T.1 N.,R. 15 W.; 75 feet north of southeast corner on west edge of road, 0.3 mile north of east and west road. Ground elevation, 1,818 feet (a); depth to water, 8.7 feet, September 9, 1939.

SOIL	3	3

	Thickness (feet)	Depth (feet)
SAND, clayey, buff	2	5
SAND, fine	3	8
GRAVEL, fine, and sand, greenish	11	19
GRAVEL, fine to medium	5	24
GRAVEL, medium, greenish; has water-worn shale and lime, also a little soft shale	6	30
GRAVEL, medium to coarse; at 34 feet high content shale and chalk (lime), much less below	11	41
SHALE, calcareous, gray (Niobrara)	4	45

31. Southeast corner of NE¼ SE¼ Sec. 4,T.1 N., R.15 W.; west side of road, 100 yards north of quarter-mile line. Ground elevation, 1,828 feet (t); depth to water, 7.5 feet, September 13, 1939.

SAND	6	6
GRAVEL, fine, and sand	4	10
GRAVEL, fine to medium	5	15
GRAVEL, medium to coarse	15	30
GRAVEL, fine	5	35
GRAVEL, medium; some coarse fine from 38 feet to 40 feet	8	43
SHALE, calcareous, gray (Niobrara)	4	47

32. SE¼ NW¼ Sec. 5,T.1 N.,R.15 W.; 100 yards south of railroad track on west side of fence. Ground elevation, 1,838 feet (a), depth to water, 11.1 feet, September 9, 1939.

SOIL, sandy	3	3
SAND, clayey, buff	2	5
CLAY, sandy, light brown	5	10
GRAVEL, medium	6	16
SHALE, calcareous, gray (Niobrara)	4	19

33. Northeast corner of SE¼ SW¼ Sec. 5,T.1 N., R.15 W.; 0.35 mile south of railroad track, east edge of field, 25 feet north of bridge. Ground elevation, 1,836 feet (t); depth to water, 8.8 feet, September 9, 1939.

SOIL, sandy	3	3
CLAY, brownish gray	5	8
GRAVEL, fine, and sand, reddish	4	12
GRAVEL, FINE, GREENISH	5	17
GRAVEL, fine to medium; large quantity water-worn shale	8	25
GRAVEL, medium, some coarse; much less shale	6	35

34. Northeast corner of SW¼ Sec. 8,T.1 N.,R.15 W.; 75 yards north of river bridge, just east of road. Ground elevation, 1,840 feet (t); depth to water, 12.2 feet, September 13, 1939.

SAND, fine	5	5
SAND, fine, silty, gray	6	11
GRAVEL, fine to medium, top part reddish, rest green	4	15
GRAVEL, medium, some coarse; large water-worn shale and chalk pieces	5	20
GRAVEL, fine	5	25
GRAVEL, medium, some coarse, green	7	32
SHALE, calcareous, gray (Niobrara)	3	35

35. Southwest corner of SW¼ Sec. 16,T.2 N.,R. 16 W.; 15 feet east of west ditch and 60 feet north of south ditch. Ground elevation, 2,060 feet (t); depth to water, not measured.

SOIL, brown	2	2
CLAY, silty, greenish yellow (Peorian)	12	14
SILT, sandy, dark buff; some erratic gravel (Loveland)	15	33
GRAVEL, fine to very coarse; coarse to predominate	16	49
SAND, clayey, buff to whitish	9	58
GRAVEL, fine to very coarse; poorly sorted, mostly fine	7	65
GRAVEL, coarse; small amount of fine	39	104
CLAY, light brown to light gray; very sticky drilling	4	108
GRAVEL, fine to coarse; mostly coarse	19	127
CLAY, mostly light gray, some pale olive green and brown	18	145
CLAY, pale green; some pieces harder and darker green with conchoidal fracture; at 157 - 157.4 a hard zone, jetted	12	157
SHALE, oily, black; very sticky and plugged the bit readily	6	163

36. Northwest corner of NE¼ NW¼ Sec. 31,T.2 N., R.16 W.; 20 feet south of road and 60 feet east of the quarter-mile fence. Ground elevation, 1,970 feet (t); depth to water, not measured.

SOIL, dark gray	2	2
CLAY, silty, yellow (Peorian)	17	19
CLAY, brown (Loveland)	1	20
CLAY, silty, gravelly, flesh-colored	10	30
CLAY, silty, gravelly, flesh-colored; some concretionary material (Loveland)	3	33
GRAVEL, fine to coarse, mostly fine and medium	5	38
CLAY, sandy, buff to whitish	5	43
GRAVEL, fine to coarse; poorly sorted	22	65
GRAVEL, fine to medium; much clear and white quartzitic material	5	70
CLAY, sandy, light grayish green; more gray at base, has apparently large, calcareous chunks of material that make difficult drilling at times	30	100
GRAVEL and sand, fine; almost entirely white and clear quartz	31	131
CHALK, first one foot soft, yellow, then gray shale	2	133

37. Northeast corner of SE¼ NE¼ Sec. 1 T.1 N., R.16 W.; north side of road, 100 feet west of Cottonwood Creek Bridge. Ground elevation, 1,857 feet (a); depth to water, 8 feet, September 21, 1939.

ROAD FILL	3	3

	Thickness (feet)	Depth (feet)
GRAVEL, coarse, reddish; some large water-worn Niobrara, lower 2 feet has more shale	17	20
SHALE, calcareous, dark bluish gray (Niobrara)	5	25

38. Southeast corner of SE¼ Sec. 2,T.1 N.,R.16 W.; 25 feet north of railroad track and 15 feet west of section line. Ground elevation, 1,853 feet (a); depth to water, caved at 12.7 feet, September 21, 1939.

SOIL	2	2
SAND, slightly clayey, buff	4	6
SAND, clayey, grayish brown	5	11
SILT, bluish gray	4	15
GRAVEL, fine, and water-worn shale	2	17
SHALE, calcareous, gray (Niobrara)	2	19

39. NW¼ Sec. 4,T.1 N.,R.16 W.; 100 yards east of Turkey Creek bridge, south side of road, 0.16 mile east of northwest corner. Ground elevation, 1,895 feet (a), depth to water, 3 feet, September 21, 1939.

ROAD FILL and soil	3	3
SAND, buff	2	5
SAND, clayey, brownish gray	1	6
GRAVEL, coarse	13	19
GRAVEL, fine	6	25
GRAVEL, medium to coarse	7	32
GRAVEL, fine; some sand and gray silty sand	6	38
GRAVEL, medium	7	45
SHALE, gray (Niobrara)	3	48

40. Northwest corner SW¼ SW¼ Sec. 6,T.1 N.,R. 16 W.; 100 feet south of railroad track on east side of road. Ground elevation, 1,878 feet (t); depth to water, 7.6 feet, October 3, 1939.

SOIL	2	2
SAND, clayey, buff	3	5
SAND, coarse, reddish	5	10
SAND, and fine gravel, gray	7	17
GRAVEL, medium, some fine, gray	6	23
SHALE, dark gray (Niobrara)	5	28

41. Southwest part of SE¼ NE¼ Sec. 7,T.1 N.,R. 16 W. Ground elevation, 1,875 feet (t); depth to water, 12.8 feet, September 21, 1939.

SAND, fine, and soil	9	9
SAND, clayey	5	14
GRAVEL, fine	6	20
GRAVEL, fine to medium	7	27
GRAVEL, medium to coarse; large water-worn shale and chalk peices	11	38
GRAVEL, medium, greenish	13	51
SHALE, calcareous, dark gray (Niobrara)	8	59

42. SW¼ Sec. 9,T.1 N.,R.16 W.; 0.55 mile north of river bridge, east side of road, opposite house foundation. Ground elevation, 1,867 feet (t); depth to water, 8 feet, September 21, 1939.

ROAD FILL	3	3
CLAY, grayish brown	4	7
SAND and fine gravel, greenish	17	24
GRAVEL, fine to medium; coarser from 35 feet down	19	44
SHALE, calcareous specks, blue gray (Niobrara)	5	49

43. Southeast corner of NW¼ Sec. 10,T.1 N.,R. 16 W.; 200 feet north of southeast corner on west side of road. Ground elevation, 1,860 feet (t); depth to water, 9.3 feet, September 21, 1939.

SAND, fine, clayey	7	7
GRAVEL, fine; some sand	8	15
GRAVEL, fine to medium, green	10	25
GRAVEL, medium; some coarser greenish	14	39
GRAVEL, fine	4	43
SHALE, calcareous, dark gray (Niobrara)	4	47

44. Southeast corner of NE¼ Sec. 12,T.1 N.,R. 16 W.; 50 feet north of corner by west fence. Ground elevation, 1,852 feet (t); depth to water, 13.8 feet, September 13, 1939.

SOIL and fine sand, slightly clayey	9	9
SAND, fine, and silt	9	18
GRAVEL, fine, greenish	22	40
GRAVEL, fine, and sand	6	46
GRAVEL, medium, greenish	5	51
SHALE, calcareous specks, gray (Niobrara)	3	54

45. Northwest corner of NE¼ NW¼ Sec. 14 T.1 N., R.16 W.; 150 feet west of Rebecca Creek and 0.23 mile north of highway. Ground elevation, 1,858 feet (a); depth to water, 12.6 feet, September 21, 1939.

SOIL	4	4
SAND, slightly clayey, light brown	8	12
SILT and fine sand	5	17
SHALE, water-worn, chalk and gravel	13	30
GRAVEL, medium well sorted mostly clear, red; some green	9	39
GRAVEL, slightly finer than above	10	49
SHALE, calcareous, bluish gray (Niobrara)	10	59

46. NW¼ NW¼ Sec. 16,T.1 N.,R.16 W.; 0.19 mile north of river bridge, 50 feet east of road and 75 feet west of barn. Ground elevation, 1,868 feet (t); depth to water, 10.1 feet, September 21, 1939.

SOIL, sandy	4	4
SAND, coarse; a little gravel	2	6
SAND, clayey, grayish brown	2	8
GRAVEL, fine and sand	4	12
GRAVEL, medium, greenish	6	18
SHALE, calcareous, bluish gray (Niobrara)	1	19

LOGS OF TEST HOLES DRILLED IN FRANKLIN COUNTY BY THE UNITED STATES BUREAU OF RECLAMATION

1-R Northeast corner of NW¼ NW¼ Sec. 35,T.2 N., R.15 W. Ground elevation, 1,933 feet (i); depth to water, not measured.

	Thickness (feet)	Depth (feet)
TOP SOIL	4	4
CLAY, yellow	11	15
CLAY, yellow	9	24
SAND, fine	4	28
CLAY, gray	12	40
SAND and gravel	20	60
SAND and gravel	4	64
CHALK, light	2	66
SHALE, blue	84	150

2-R Northwest corner of NE¼ Sec. 2,T.1 N.,R.15 W. Ground elevation, 1,866 feet (i); depth to water, not measured.

TOP SOIL	5	5
CLAY, yellow	20	25
SAND, fine	5	30
SAND and gravel	22	52
SHALE, blue	38	90

3-R Northeast corner of NW¼ SE¼ Sec. 2,T.1 N., R.15 W. Ground elevation, 1,818 feet (i); depth to water, not measured.

TOP SOIL	4	4
SAND, fine	6	10
SAND, coarse	26	36
SAND and gravel	7	43
SHALE, blue	27	70

4-R Southwest corner of SE¼ SE¼ Sec. 2,T. 1 N., R.15 W. Ground elevation, 1,814 feet (i); depth to water, not measured.

SAND, blow, white	4	4
SILT, black	1	5
SAND, fine	5	10
SAND, coarse	26	36
SAND, coarse, and gravel	4	40
SHALE, blue	29	69

5-R Northwest corner of SE¼ SE¼ Sec. 35,T.2 N., R.16 W. Ground elevation, 1,980 feet (i); depth to water, not measured.

TOP SOIL	5	5
CLAY, yellow	62	67
SHALE, brown	2	69
SAND	20	89
SHALE, blue	61	150

6-R Southwest corner of NE¼ Sec. 2,T.1 N.,R.16 W. Ground elevation, 1,922 feet (i); depth to water, not measured.

TOP SOIL and clay	10	10
CLAY, brown	10	20
CLAY, black	5	25
CLAY, brown	26	51
SAND, white	22	73
SHALE, blue	24	97

7-R Southwest corner of SE¼ Sec. 2,T.1 N.,R. 16 W. Ground elevation, 1,905 feet (i); depth to water, not measured.

TOP SOIL	5	5
CLAY, silty, yellow	30	35
SAND, white	20	55
SAND, white, and coarse gravel	3	58
SHALE, blue	26	84

8-R Northeast corner of NW¼ SW¼ NE¼ Sec. 11, T.1 N.,R.16 W. Ground elevation, 1,855 feet (i); depth to water, not measured.

TOP SOIL	5	5
SAND	20	25
SAND and gravel	12	37
SHALE, blue	103	140

9-R Southeast corner of SW¼ NE¼ Sec. 11,T.1 N., R.16 W. Ground elevation, 1,853 feet (i); depth to water, not measured.

TOP SOIL	6	6
SAND, fine	4	10
SAND and gravel	35	45
SHALE, blue	20	65

10-R Southwest corner of SE¼ SE¼ Sec. 11,T.1 N., R.16 W. Ground elevation, 1,878 feet (i); depth to water, not measured.

DIRT, black, and yellow clay	10	10
CLAY, yellow	15	25
SILT, black and yellow	10	35
SILT, black	17	52
SAND, white	3	55
SAND, coarse	18	73
SHALE, blue	25	98

11-R Northwest corner of NE¼ NE¼ SE¼ NE¼ Sec. 14, T.1 N.,R.16 W. Ground elevation, 1,960 feet (i); depth to water, not measured.

TOP SOIL	5	5
CLAY, yellow	7	12
SHALE, yellow	3	15
SHALE, blue and yellow	10	25
SHALE, blue	65	90
SAND	1	91
SHALE, blue	59	150

(t) Elevations estimated from topographic map.
(a) Elevations obtained by altimeter levels.
(i) Elevations established by instrumental levels.

12-R Southeast corner of NE¼ Sec. 6,T.1 N., R.16 W. Ground elevation, 1,990 feet (i); depth to water, not measured.

	Thickness (feet)	Depth (feet)
TOP SOIL	5	5
SAND, very fine, silty	10	15
SAND, very fine	30	45
SAND, fine	10	55
SHALE, soft, brown	10	65
SAND, soft, fine	2	67
SAND, fine	6	73
SAND and gravel	3	76
SHALE, blue	99	175

13-R Northeast corner of SE¼ SE¼ SE¼ Sec. 6,T.1 N.,R.16 W.; on south side of river. Ground elevation, 1,877 feet (i); depth to water, not measured.

	Thickness (feet)	Depth (feet)
SAND, fine	10	10
SAND and gravel	16	26
SHALE, blue	25	51

14-R SE¼ NE¼ SE¼ Sec. 7,T.1 N.,R.16 W. Ground elevation, 1,876 feet (i); depth to water, not measured.

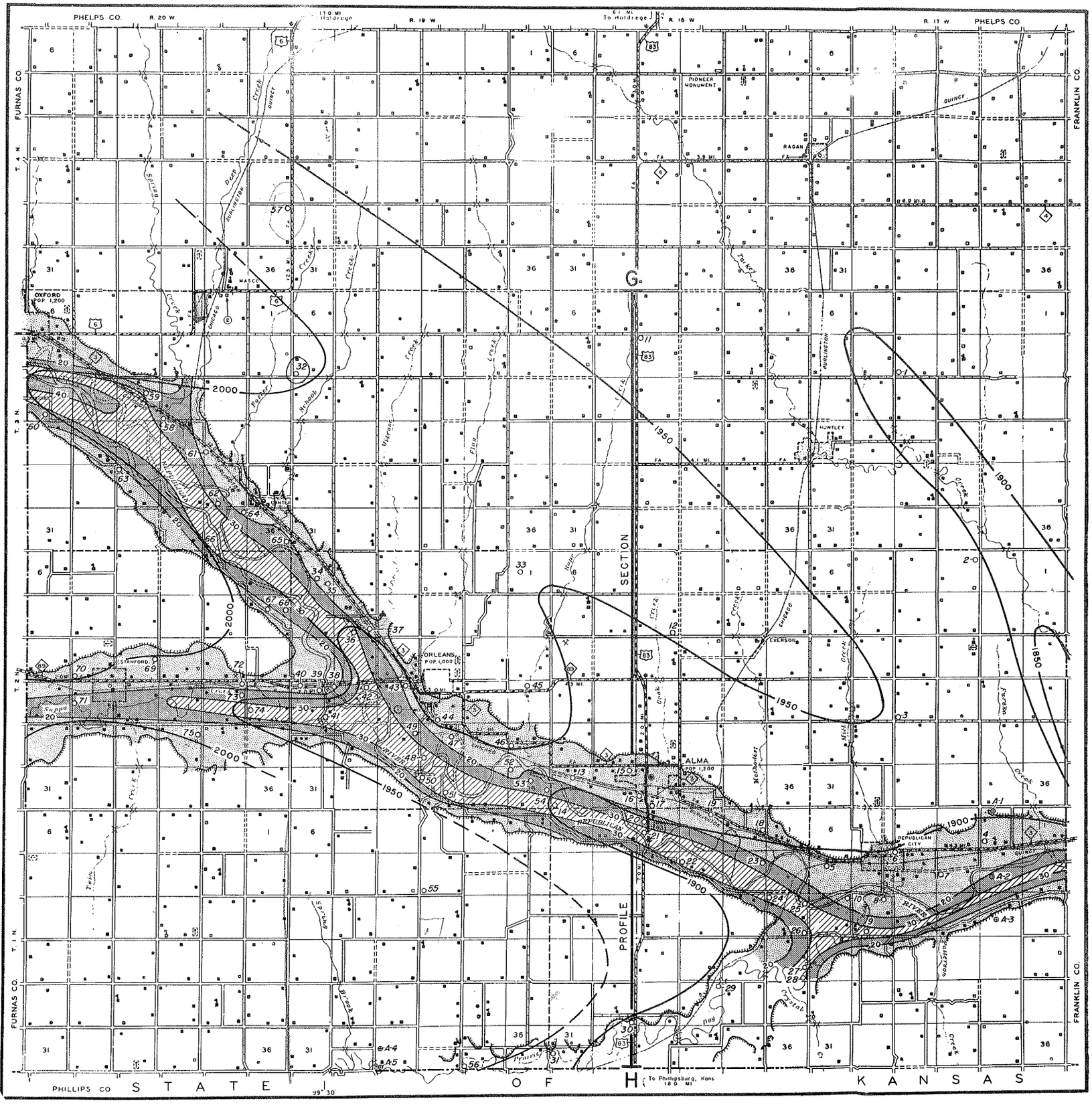
	Thickness (feet)	Depth (feet)
SAND, fine	30	30
SILT	5	35
SAND, coarse	5	40
SAND and gravel	10	50
SHALE, blue	30	80

15-R Northwest corner of NE¼ NE¼ NE¼ Sec. 18, T.1 N.,R.16 W. Ground elevation, 1,933 feet (i); depth to water, not measured.

	Thickness (feet)	Depth (feet)
TOP SOIL	5	5
CLAY, silty, yellow	40	45
CLAY, yellow	4	49
SAND	6	55
SAND and gravel	4	59
SHALE, yellow	2	61
SHALE, blue	29	90

16-R SE¼ NE¼ Sec. 18,T.1 N.,R.16 W. Ground elevation, 1,900 feet (i); depth to water, not measured.

	Thickness (feet)	Depth (feet)
TOP SOIL	5	5
CLAY, silty, yellow	50	55
SAND	6	61
SHALE, brown	4	65
SHALE, brown and blue	3	68
SHALE, blue	107	175



GROUND-WATER MAP
REPUBLICAN VALLEY REGION AND VICINITY
HARLAN COUNTY, NEBRASKA

LEGEND

Approximate thickness of saturated water-bearing sand and gravel in the valley of the Republican River and the valleys of its chief tributaries, in feet:

0-20	30-40	50-60
20-30	40-50	More than 60

N

14 ○ Cooperative Ground-water Survey test holes

A-1 ⊕ Corps of Engineers, U.S. Army, Core-drill holes

R-1 ● U.S. Bureau of Reclamation test holes

—1700— Contour showing the top of the relatively impervious Cretaceous bedrock; elevations referred to mean sea level and based largely on instrumental levels and partly on topographic maps (contours dashed in areas of poor control)

Prepared by: CONSERVATION AND SURVEY DIVISION, UNIVERSITY OF NEBRASKA
BUREAU OF IRRIGATION, WATER POWER, AND DRAINAGE; NEBRASKA DEPARTMENT OF ROADS AND IRRIGATION
GEOLOGICAL SURVEY, UNITED STATES DEPARTMENT OF INTERIOR

Base map after General Highway and Transportation map, Nebraska Department of Roads and Irrigation

SCALE
0 1 2 3 4 5 MILES

1944

2150

GROUND-WATER CONDITIONS IN HARLAN COUNTY

Test-drilling in Harlan County was confined principally to the southern two-thirds of the county. This part of the county may be divided into three generalized ground-water regions: (1) the area north of the Republican Valley, (2) the bottomland region including the Republican Valley and the tributary valleys of Prairie Dog Creek and Sappa Creek, and (3) the region south of the Republican Valley, which may be subdivided into three areas separated from each other by Prairie Dog and Sappa creeks.

The area north of the Republican Valley in Harlan County (See Ground-Water Map of Harlan County) differs from the eastward extension of this area in Franklin, Webster, and Nuckolls counties in the presence of relatively thick deposits of sand and gravel which underlie much of the upland (Geologic Profile Section G-H). The contours on top of the relatively impervious bedrock show that a narrow buried channel, trending southeastward, is present in the eastern part of the county. The axis of this channel roughly coincides with the lower course of Turkey Creek from a point about 2½ miles east of Huntley continuing southeastward to a point on the Harlan-Franklin county line 8½ miles north of the Nebraska-Kansas state line. The contours also show a small tributary channel trending southeastward which joins the Republican Valley in the vicinity of Alma, and indicate the presence of a bedrock ridge trending southeastward from a point on the Harlan-Furnas county line 5 miles south of the northwest corner of Harlan County to a point about 3 miles north of Republican City. The axis of this buried ridge is approximately parallel to the axis of the Republican Valley in the western half of the county. The logs of test holes 12 and 32, drilled along this ridge, show that relatively thick deposits of sand and gravel were encountered above the bedrock. The thickness of the sand and gravel deposits increases northward as shown by the log of Test Hole 11 and the Geologic Profile Section G-H. In Harlan County the sand and gravel deposits north of the Republican Valley are capped by a relatively thick mantle of loess except where streams tributary to the Republican River have cut through the loess mantle. As a result, recharge of the ground-water reservoir from local precipitation is limited. It is believed that because of these circumstances the intensive development of large ground-water supplies in the area north of the Republican Valley will necessarily be restricted.

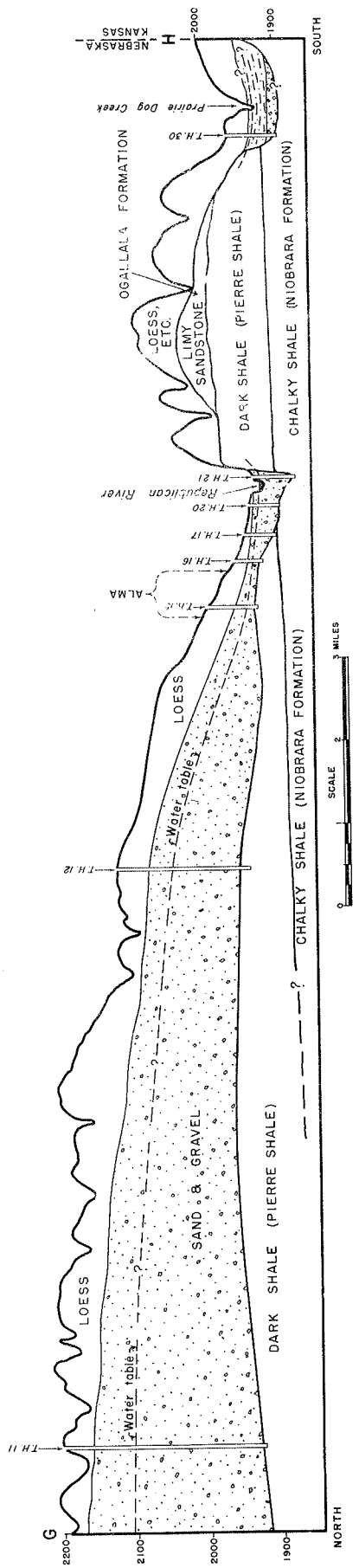
The Republican Valley has an average width of about 2 miles throughout its course across the county. The tributary valleys of Prairie Dog and Sappa creeks which join the Republican Valley in Harlan County are not as wide as the Republican and average a little more than a mile in width near their respective mouths.

The Republican Valley in Harlan County is characterized by a buried channel with relatively low bedrock and comparatively thick overlying deposits of water-bearing sand and gravel. From the junction of Sappa Creek and the Republican River, eastward to the Franklin County line, the deepest part of this fill is located near the southern limit of the Valley. The approximate thicknesses of saturated water-bearing sand and gravel in this region are shown on the Ground Water Map of Harlan County by means of shaded patterns. The map shows that the maximum thickness of saturated water-bearing material occurs in a narrow tongue located south of Oxford and extending eastward into the county for a distance of about 2 miles. The approximate thickness of saturated water-bearing sand and gravel in the valley of Sappa Creek has also been shown by means of shaded patterns. In Prairie Dog Creek valley the thickness of saturated water-bearing material has been shown only for a distance of about 2 miles above the junction of Prairie Dog Creek and the Republican River because there was not sufficient test-hole control to warrant showing thicknesses for the entire valley. The water table in the Republican Valley region and in the valleys of Sappa and Prairie Dog creeks is at a relatively shallow depth. In this region optimum conditions prevail for the infiltration of precipitation that falls in the region, because the clay bed overlying the more permeable sands and gravels is in most places comparatively thin or absent. Conditions are likewise favorable in this region for direct recharge to the ground-water reservoir from stream flow. In addition the ground water in the Republican Valley receives steady contributions from upland areas north of it in the form of water moving in toward the Valley (see Geologic Profile Section G-H).

The region south of the Republican Valley may be subdivided into 3 parts separated from each other by Sappa and Prairie Dog creeks. All 3 areas are similar hydrologically and in general are characterized by relatively high shale bedrock (Pierre shale) which is overlain by limy sandstone and lime-cemented silts of the Ogallala formation capped by loess (Geologic Profile Section G-H). The possibilities of infiltration in this loess-covered region are poor. In the divide area between the Republican Valley and Sappa Creek Valley the more permeable materials overlying the shale bedrock are subject to natural leakage along the valley sides of the Republican Valley and the Sappa Valley. Similarly, the permeable material overlying the shale bedrock in the area south of the Republican Valley lying between Sappa and Prairie Dog creeks is subject to natural leakage along the valley sides surrounding the area (Geologic Profile Section G-H). The area south of the Republican Valley east of Prairie Dog Creek is also characterized by high shale bedrock and the thin overlying deposits of more permeable material are susceptible to leakage along the valley sides.

In places where the shale bedrock and the limy sandstone and silts of the Ogallala formation are overlain by thin deposits of unconsolidated sand and gravel, there are possibilities of developing small water supplies where the water table is up in the more permeable materials.

The general conditions in the three principal ground-water regions in Harlan County are shown in the following geologic profile section:



This section is located at the west edge of Alma and extends in a north-south direction from a point 18 miles north of the Nebraska-Kansas state line (G) to the Nebraska-Kansas state line (H). Note the great thicknesses of sand and gravel north of the Republican Valley, increasing northward between test holes 12 and 11; the bedrock ridge north of the test hole 12; the relatively good infiltration area immediately north and south of the Republican River between test holes 16 and 21; the high shale bedrock (Pierre shale) south of the valley, overlain by limy sandstone and silt of the Ogallala formation (Tertiary age); and the relatively thick mantle of loess capping the upland areas and intermediate slopes both north and south of the Republican Valley. The dashed line representing the water table indicates that the water table slopes southward toward the Republican Valley in the region north of the Valley. The dark shale is part of the Pierre shale and is underlain by chalky shale of the Niobrara formation, both of Cretaceous age. Both formations are relatively impervious.

LOGS OF TEST HOLES DRILLED IN HARLAN COUNTY BY THE CONSERVATION AND SURVEY DIVISION AND THE FEDERAL GEOLOGICAL SURVEY

1. SW¼ Sec. 9,T.3 N.,R.17 W.; 470 feet east of southwest corner of section on north edge of road. Ground elevation, 2,160 feet (a); depth to water, 118 feet, October 18, 1941.

	Thickness (feet)	Depth (feet)
SILT, sandy, buff (Peorian)	15	15
SAND, silty, dark reddish brown	4	19
SAND, silty, reddish buff	10	29
SAND, silty, reddish buff; some limy concretions	6	35
SAND, very fine, reddish; hard to get sample	32	67
SAND, fine, reddish; some clay, most of the material goes into the mud	34	101
SAND, fine to coarse, reddish; some gravel	4	105
GRAVEL, fine to very coarse, red; very good	9	114
CLAY, sand, tan	2	116
GRAVEL, fine to coarse, red; very good	39	155
GRAVEL, fine to coarse; has large pebbles that are broken by the drill; very good	37	192
CLAY, sandy, soft	3	195
GRAVEL, fine to coarse, red; has large pebbles, much of the gravel is broken by the drill; very good	30	225
GRAVEL, fine to coarse, red; good; very thin clay seam at about 225 feet	21	246
CLAY, sandy, soft, gray	2	248
GRAVEL, fine to coarse, clean, red; good, many broken fragments of gravel	21	269
SHALE, dark gray to black	11	280

2. Northeast corner of SE¼ NE¼ Sec. 3,T.2 N.,R. 17 W.; west edge of road, opposite gate to pasture, edge of upland; 2 miles east and 7 miles north of Republican City. Ground elevation, 2,160 feet (a); depth to water, 110 feet, October 18, 1941.

	Thickness (feet)	Depth (feet)
ROAD FILL and buff silt; cuts granular (Peorian)	15	15
SILT, sandy, soft, buff (Peorian)	3	18
SILT, dark reddish brown; old soil	5	23
SILT to silty sand, reddish buff	6	29
SAND, very fine, silty, reddish buff; some limy concretions	9	38
GRAVEL, limestone pebbles, sandstone pebbles	3	41
SAND, some coarse, reddish; some silt or clay	4	45
SAND, fine, silty, reddish buff; some limy streaks	8	53
SAND, silty, limy, reddish gray	4	57
GRAVEL, fine to very coarse, red; good	27	84
CLAY, sandy, reddish buff	1	85
GRAVEL, fine to coarse, red; good	22	107
CLAY, compact, brown	5	112
GRAVEL, fine to coarse, red; finer than above; good	15	127
CLAY, sandy, soft, gray tan	1	128
GRAVEL, fine to coarse, red; good	33	161
SAND, clayey, soft, tan	2	163
GRAVEL, fine to coarse, mostly medium, red; good	16	179
CLAY, sandy, grayish tan	9	188
SAND, clayey, reddish	3	191
GRAVEL, fine to medium, red	7	198
CLAY, sandy, grayish tan	1	199
GRAVEL, fine to very coarse, red; good	12	211
CLAY, sandy, reddish brown	3	214
GRAVEL, fine to medium, red; some coarse; good	5	219
CLAY, sandy, very sticky, compact, gray	12	231
GRAVEL, fine to coarse, red	2	233
CLAY, sandy, sticky, compact, gray	6	239
GRAVEL, fine to coarse, mostly medium, compact, greenish yellow; much clear quartz	12	251
SHALE, tough, sticky, black	9	260

3. Southwest corner of Sec. 21,T.2 N.,R.17 W.; 60 feet east of corner on north edge of road; 3 miles north of Republican City. Ground elevation, 2,100 feet (a); depth to water, 98 feet, October 18, 1941.

	Thickness (feet)	Depth (feet)
ROAD FILL	2	2
SILT, buff (Peorian)	15	17
SILT, dark reddish brown (old soil)	4	21
SILT, clayey, reddish buff	9	30
SILT, clayey, soft, gray buff; some lime	13	43
CLAY, hard, compact, gray buff	5	48
SAND, soft, brown; greenish at 55 feet	9	57
GRAVEL, fine to coarse, clean, light greenish yellow, clear and pink	8	65
CLAY, sandy, limy, very tough, white	2	67
CLAY, sandy, gray	4	71
GRAVEL, fine to coarse, clean, pink	34	105
GRAVEL, fine to coarse, clean, greenish yellow predominance; some red and pink; thin clay seam at 105 feet	13	118
CLAY, sandy, gray; some gravel in upper part	6	124
CLAY, tough, sticky, light tan; some limy streaks	6	130
CLAY, sticky, tough, light tan to pinkish tan	11	141

(t) Elevations estimated from topographic map.
(a) Elevations obtained by altimeter levels.
(i) Elevations established by instrumental levels.

	Thickness (feet)	Depth (feet)
CLAY, sandy, grayish tan, some fine gravel	4	145
GRAVEL, fine to medium; mostly clear, some yellow, green and red	7	152
SHALE, black (Pierre)	8	160

4. SW¼ Sec. 2,T.1 N.,R.17 W.; 0.15 mile north of southwest corner on east edge of road. Ground elevation, 1,928 feet (t); depth to water, caved at 39 feet, October 3, 1939.

ROAD FILL	2	2
SAND, clayey, buff	21	23
SAND, clayey, gray	4	27
GRAVEL, fine to medium	13	40
GRAVEL, medium, good	13	53
SHALE, gray (Niobrara)	5	58

5. SE¼ NW¼ Sec. 7,T.1 N.,R.17 W.; 0.12 mile south of railroad, 100 feet east of abandoned brown house. Ground elevation, 1,909 feet (t); depth to water, 10.4 feet, October 14, 1939.

SOIL and buff sand; some clay	4	4
SAND and fine gravel	5	9
GRAVEL, fine; some sand	6	15
GRAVEL, medium, gray	5	20
SHALE, gray (Niobrara)	7	27

6. NW¼ NW¼ Sec. 9,T.1 N.,R.17 W.; 0.15 mile east of northwest corner. Ground elevation, 1,940 feet (t); depth to water, caved at 31.5 feet, October 3, 1939.

SOIL	2	2
SAND, clayey, buff	20	22
SAND, clayey, light chocolate gray (loess-like)	8	30
SAND, coarse, clayey, gray	7	37
GRAVEL, medium, yellow; some clay	8	45
SHALE, greenish black (Pierre)	4	49

7. SW¼ Sec. 10, T.1 N.,R.17 W.; 0.12 mile south of northwest corner of quarter. Ground elevation, 1,903 feet (t); depth to water, 11.5 feet, October 3, 1939.

SOIL, sandy	3	3
SAND, buff	3	6
CLAY, sandy, dark brown	3	9
SAND, fine, buff	3	12
GRAVEL, fine to medium; water-worn shale (Pierre and Niobrara)	6	18
SHALE, dark greenish black (Pierre)	1	19

8. Northwest corner of NE¼ NE¼ Sec. 17,T.1 N., R.17 W.; 0.2 mile south of bridge at end of north-south road. Ground elevation, 1,900 feet (t); depth to water, dry at 5.5 feet, October 3, 1939.

SOIL, sandy	2	2
SOIL, black	1	3
SAND, brownish gray	2	5
GRAVEL and water-worn shale	1	6
SHALE, gray (Niobrara?)	2	8

	Thickness (feet)	Depth (feet)

9. Center west edge of SE¼ SW¼ Sec. 17,T.1 N., R.17 W.; 0.2 mile northeast of bridge across Prairie Dog Creek and on east bank of creek. Ground elevation, 1,905 feet (t); depth to water, 18.6 feet, September 28, 1939.

SOIL, sandy	3	3
SAND, clayey, buff	4	7
SAND, clayey, gray	3	10
SAME as above with more clay	5	15
SAND, clayey, light brown	2	17
SILT, blue	10	27
SAND and fine gravel, green	5	32
GRAVEL, fine to medium	7	39
GRAVEL, medium, some coarse	16	55
SHALE, gray (Niobrara)	3	58

10. Northeast corner of Sec. 18,T.1 N.,R.17 W.; 60 feet south of river in southwest corner of intersection. Ground elevation, 1,905 feet (t); depth to water, caved at 12 feet, September 28, 1939.

SAND, fine, cemented	5	5
GRAVEL, medium, reddish	8	13
GRAVEL, medium, green to gray	8	21
SHALE, gray (Niobrara)	4	25

11. NW¼ Sec. 9,T.3 N.,R.18 W.; 0.1 mile east of northwest corner. Ground elevation, 2,220 feet (t); depth to water, 115.2 feet, October 18, 1941.

ROAD FILL	2	2
SILT, buff (Peorian)	21	23
SILT, dark reddish brown; old soil	4	27
SILT, clayey, reddish buff; has limy concretions in lower part	11	38
SAND, silty, reddish buff; some coarse sand	12	50
SAND, slightly silty or clayey, reddish buff; has hard sandy lime concretions or sandstone	17	67
SAND, clayey, compact, reddish buff	6	73
GRAVEL, fine to very coarse, clean, mostly red	17	90
CLAY, sandy, reddish	1	91
GRAVEL, fine to coarse, clean, red; very good; very thin clay seam at 135 feet	53	144
CLAY, sandy, reddish buff	15	159
CLAY, sandy, limy, hard, whitish buff	1	160
CLAY, silty, pinkish tan	8	168
CLAY, sandy, limy, whitish gray to pink	9	177
SANDSTONE, grayish green	4	181
CLAY, sandy, greenish gray; hard limy concretions or thin layers	6	187
CLAY, sandy, greenish gray; cuts in large pieces	6	193
SANDSTONE, greenish gray	13	206
SAME as above but containing gravel	2	208
GRAVEL, fine to medium, mostly red	5	213

	Thickness (feet)	Depth (feet)
CLAY, sandy, greenish gray; contains some lime	13	226
GRAVEL, fine to medium, well sorted, mostly greenish yellow, clear, some red, a dark gravel; very thin clay seam at 280 feet	60	286
SHALE, tough, plastic, light gray to black; rusty at contact	4	290

12. SE¼ Sec. 9,T.2 N.,R.18 W.; 0.17 mile west of southeast corner on north edge of road. Ground elevation, 2,120 feet (t); depth to water, 73 feet, October 18, 1941.

SILT, dark brownish gray and buff (Peorian)	19	19
CLAY, silty, dark reddish buff	5	24
SILT and clay, reddish buff	4	28
CLAY, silty, limy, whitish gray	5	33
SAND, silty, clayey, reddish buff	2	35
CLAY, sticky, compact, whitish to gray buff	4	39
CLAY, sandy, silty, gray brown to reddish	5	44
SAND, coarse, clayey, gray brown	3	47
SAND, coarse, clayey, gray; limy streaks	4	51
GRAVEL, fine to coarse, red	8	59
GRAVEL, fine to very coarse, red; some clay at 59 feet	15	74
GRAVEL, fine to very coarse, dark red; good	12	86
CLAY, compact, reddish buff	3	89
CLAY, hard, limy and limestone, white, hard, compact	4	93
CLAY, sandy, greenish	3	96
CLAY, tough, compact, gray brown to slightly pink, some slightly green; has limy concretions	11	107
CLAY, compact, tough, sticky, tan	3	110
SAND, limy and limestone, hard, whitish gray (mudstone)	2	112
SAND, coarse, clayey, sticky, gray; cuts large pieces	10	122
GRAVEL, fine to medium, mostly clear quartz; has some greenish yellow and pink	10	132
CLAY, sandy, soft, gray	1	133
GRAVEL, fine to medium, mostly clear quartz; some greenish yellow and pink	13	146
GRAVEL, fine, medium, coarse, mostly clear quartz, has more greenish yellow and red gravel than above	13	159
CLAY or weathered shale, soft, tan	5	164
SHALE, compact, sticky, ochre to rusty to light gray	3	167
SHALE, compact, tough, plastic, black; thin hard layer at 178 feet, (Pyrite) iron concretion	13	180

13. Southeast corner of NE¼ NW¼ Sec. 31,T.2 N., R.18 W.; 60 feet south of railroad on north edge of road. Ground elevation, 1,948 feet (t); depth to water, caved at 8 feet, October 21, 1939.

SOIL, sandy, and fine clayey sand	6	6
GRAVEL, fine, and sand, reddish	4	10
GRAVEL, medium, green gray; some water-worn shale	8	18
SHALE, black (Pierre)	2	20

14. SW¼ Sec. 31,T.2 N.,R.18 W.; 0.1 mile north of southwest corner on east edge of road. Ground elevation, 1,945 feet (t); depth to water, 10 feet, October 21, 1939.

SOIL, sandy, and fine sand	7	7
SAND and fine gravel, reddish	3	10
GRAVEL, fine to medium and sand	17	27
GRAVEL, slightly coarser than above, gray	8	35
GRAVEL, medium, some coarse	11	46
SHALE, black to gray (Pierre)	3	49

15. Center of NE¼ NE¼ Sec. 32,T.2 N.,R.18 W.; north edge of golf course. Ground elevation, 1,980 feet (t); depth to water, caved at 35 feet, October 21, 1939.

SOIL	4	4
SAND, clayey, buff	22	26
SAND, clayey, brown	6	32
SAND, clayey, fine	4	36
GRAVEL, fine to medium; seems to be some cementing material, less from 43 feet	14	50
SHALE, black (Pierre)	3	53

16. Center west edge of NW¼ SW¼ Sec. 23,T.2 N., R.18 W.; 150 feet south of railroad and 10 feet east of section line. Ground elevation, 1,945 feet (t); depth to water, 11.5 feet, October 9, 1939.

SOIL, sandy	4	4
SOIL, black	3	7
SAND, fine, buff	7	14
GRAVEL, coarse	6	20
SHALE, greenish black (Pierre)	5	25

17. Southwest corner of SW¼ SW¼ Sec. 33,T.2 N., R.18 W.; 50 feet east of highway. Ground elevation, 1,935 feet (t); depth to water, 14 feet, October 9, 1939.

SOIL, sandy	2	2
SOIL, sandy, black	2	4
SAND, clayey, buff	7	11
SAND, silty, gray	4	15
SAND, fine	4	19
GRAVEL, medium	9	28
SHALE, greenish black (Pierre)	7	35

18. Southeast corner of NW¼ Sec. 2,T.1 N.,R.18 W.; 65 feet north of center of highway on west edge of county road. Ground elevation, 1,940 feet (t); depth to water, 20 feet, October 14, 1939.

SOIL	5	5
SAND, clayey, buff	11	16
SAND, clayey, brown; light colored sand just above gravel	9	25

	Thickness (feet)	Depth (feet)
GRAVEL, coarse, light colored	3	28
SHALE, black (Pierre)	7	35

19. Center of NW¼ NE¼ Sec. 3,T.1 N.,R.18 W.; 15 feet north of center of railroad bridge in small drainage. Ground elevation, 1,930 feet (t); depth to water, 6.5 feet, October 21, 1939.

SOIL and clayey sand	6	6
GRAVEL, medium to coarse	5	11
SHALE, black (Pierre)	8	19

20. Northeast corner of SW¼ NW¼ Sec. 4,T.1 N., R.18 W.; west edge of highway and 20 feet south of ¼ mile line. Ground elevation, 1,934 feet (t); depth to water, 7 feet, October 14, 1939.

SOIL and fine sand	5	5
SAND	5	10
GRAVEL, medium, some coarse, good	10	20
GRAVEL, fine; some coarser	9	29
GRAVEL, medium to coarse; good	7	36
SHALE, gray (Niobrara)	3	39

21. Center east edge of NW¼ SW¼ Sec. 4,T.1 N., R.18 W.; west edge of highway, 0.25 mile north of river bridge. Ground elevation, 1,931 feet (t); depth to water, 8.8 feet, October 14, 1939.

SAND, fine; soil at top	7	7
GRAVEL, fine	3	10
GRAVEL, medium; large pieces shale	10	20
GRAVEL, medium	11	31
GRAVEL, medium to coarse	9	40
GRAVEL, medium to coarse	5	45
SHALE, gray (Niobrara)	3	48

22. Northwest corner of SW¼ NW¼ Sec. 10,T.1 N., R.18 W.; 100 yards east of farmhouse; 100 yards south and 50 yards east of northwest corner. Ground elevation, 1,937 feet (t); depth to water, 16.4 feet, October 21, 1939.

SOIL	2	2
SAND, clayey, buff	15	17
GRAVEL, fine to medium	8	25
GRAVEL, medium; some coarse fine, 38 feet to 41 feet	25	50
SHALE, gray (Niobrara)	5	55

23. Southeast corner of NE¼ NE¼ Sec. 11,T.1 N., R.18 W.; 0.52 mile south of railroad. Ground elevation, 1,915 feet (t); depth to water, 8 feet, October 21, 1939.

SOIL, fine, silty	1	1
SOIL, sandy, dark brownish black	3	4
CLAY, sandy, brownish gray	2	6
GRAVEL, fine, and sand	4	10
GRAVEL, medium, grayish green; a few pieces clay or shale at 19 feet	11	21
GRAVEL, fine to medium	5	26
GRAVEL, coarse	2	28
SHALE, calcareous, gray (Niobrara)	1	29

24. Northwest corner of Sec. 13,T.1 N.,R.18 W.; 70 feet east of corner on south edge of road. Ground elevation, 1,915 feet, (t); depth to water, 10.5 feet, October 9, 1939.

SOIL and fine clayey sand	5	5
GRAVEL, fine to medium, reddish	5	10
SAND and fine gravel	9	19
GRAVEL, fine to medium	11	30
GRAVEL, medium; drilled like some coarse gravel, not much coarse gravel in sample because mud too sandy	16	46
SHALE, gray (Niobrara)	3	49

25. Southeast corner of NE¼ Sec. 13,T.1 N.,R.18 W.; between road and river, just west of section line. Ground elevation, 1,915 feet (t); depth to water, caved at 11 feet, October 3, 1939.

SAND and sandy soil	5	5
SAND and fine gravel	2	7
GRAVEL, medium, reddish	6	13
GRAVEL, medium to coarse, greenish; some water-worn shale	7	20
GRAVEL, fine, greenish	5	25
GRAVEL, medium, greenish	4	29
GRAVEL, finer than above, greenish	6	35
GRAVEL, medium, greenish	10	45
SHALE, gray and greenish black (Niobrara? Pierre?)	4	49

26. Southeast corner of Sec. 13,T.1 N.,R.18 W. Ground elevation, 1,924 feet (t); depth to water, 25.3 feet, October 3, 1939.

SOIL and road fill	5	5
SAND, clayey, buff; sticky from 19 feet	27	32
SAND and fine gravel	6	38
GRAVEL, fine	6	44
SHALE, gray (Niobrara)	5	49

27. Northeast corner SE¼ Sec. 24,T.1 N.,R.18 W. 50 feet south of bridge over Prairie Dog Creek on west side of road. Ground elevation, 1,912 feet (t); depth to water, 16 feet, October 3, 1939.

ROAD FILL, soil and sand	5	5
SAND, fine	10	15
SAND, clayey; lower foot or so blue silt (muck)	9	24
GRAVEL, fine	6	30
GRAVEL, fine to medium; some water-worn shale	9	39
SHALE, gray (Niobrara)	3	42

28. Southeast corner of Sec. 24, T.1 N.,R.18 W.; 25 feet west of road and 50 feet north of section line fence. Ground elevation, 1,922 feet (t); depth to water, 18.4 feet, October 9, 1939.

SOIL and buff sand	5	5
SAND, clayey, brownish	18	23

	Thickness (feet)	Depth (feet)
SAND, silty, blue to gray	6	29
GRAVEL, fine; water-worn shale; a little coarser gravel	12	41
SHALE, gray (Niobrara?)	4	45

29. Northeast corner of Sec. 27, T.1 N.,R.18 W.; 150 feet west of Prairie Dog Creek, on south side of road, in ditch. Ground elevation, 1,932 feet (t); depth to water, 15.3 feet, October 9, 1939.

SOIL, clayey, dark	7	7
SAND, clayey, fine, buff (loess)	9	16
SAND, fine	4	20
GRAVEL, fine; high percentage of water-worn shale and chalk 20 to 25 feet	10	30
GRAVEL, medium; some coarse	9	39
GRAVEL; same as above, but contains some large water-worn shale and chalk	4	43
SHALE, gray (Niobrara?)	6	49

30. Center of SE¼ SE¼ Sec. 29,T.1 N.,R.18 W. Ground elevation, 1,960 feet (t); depth to water, 33.6 feet, October 9, 1939.

SOIL	1	1
SAND, clayey, buff	16	17
SAND, clayey, reddish brown (loess)	13	30
SAND; finer, clayey than above, sticky, soft	10	40
CLAY, sandy, brownish gray	11	51
CLAY, silty, blue	5	56
GRAVEL, medium	9	65
SHALE, greenish black; a little gray (Pierre?)	4	69

31. SW¼ Sec. 31,T.1 N.,R.18 W.; 0.4 mile north of southwest corner, 70 feet south of Prairie Dog Creek, in east ditch. Ground elevation, 2,000 feet (t); depth to water, 16 feet, October 9, 1939.

SOIL	2	2
SAND, clayey, buff	12	14
SAND, fine (No sample)	3	17
GRAVEL, fine to medium	12	29
GRAVEL, medium; some coarse also some water-worn shale	5	34
GRAVEL, and much shale (drilled easy)	21	55
SHALE, firm, black (Pierre)	4	59

32. Southwest corner of Sec. 7,T.3 N.,R.19 W.; 100 feet east of corner on north edge of road. Ground elevation, 2,180 feet (t); depth to water, 76 feet, October 18, 1941.

SOIL, clayey, dark brown	4	4
SILT, buff (Peorian)	18	22
SILT, buff to reddish	2	24
SILT, clayey, dark reddish, brown	3	27
SILT and sandy clay, reddish buff	17	44
SILT and sandy clay, reddish buff; a few limy concretions	12	56
SAND, silty, buff to reddish; thin limy streaks	12	68
GRAVEL, fine to medium, red	3	71
CLAY, compact, brownish buff	8	79
CLAY, sandy, compact, gray	7	86
GRAVEL, fine to coarse, good, mostly red; some clear quartz	12	98
CLAY, sandy, gray	4	102
SAME but very thin limy streaks at 102 and 104 feet	2	104
CLAY, sandy, tan to pinkish	6	110
CLAY, sandy, gray	5	115
CLAY, sandy, compact, tan to pinkish	12	127
GRAVEL, fine to medium, mostly clear quartz; some greenish yellow and pink	13	140
GRAVEL, fine to coarse, mostly clear quartz; some yellowish green, pink and red	13	153
CLAY, compact, greenish gray	10	163
GRAVEL, and gray sandy clay, compact (red gravel)	2	165
SHALE, light gray to rusty	10	175
SHALE, light gray to rusty; hard rusty streak at 175 feet	6	181
SHALE, plastic, dark gray to black, slight greenish cast	9	190

33. Northeast corner of NW¼ SW¼ Sec. 1,T.2 N., R.19 W.; 300 feet west of corner and 50 feet east of fence corner. Ground elevation, 2,150 feet (t); depth to water, 117 feet, October 18, 1941.

SOIL, black	2	2
SILT, buff (Peorian)	16	18
SILT, dark reddish brown (old soil)	6	24
SILT and silty clay, reddish buff	24	48
CLAY, silty, sticky, limy, whitish buff	6	54
SILT and silty sand, soft, reddish buff	9	63
SILT, sandy, reddish buff; has hard sandy concretions	21	84
SAND, silty, limy, whitish buff; hard sandy concretions	4	88
SAND, silty, reddish buff; a few small sandy concretions	4	92
SAND, silty, reddish buff; more sandy lime concretions than above	7	99
SAND, silty, clayey, reddish buff; no concretions	9	108
SAND, clayey, reddish buff; some sandy clay	12	120
GRAVEL, fine to coarse, red; some clear and yellowish	10	130
GRAVEL, medium to coarse, red; very good, coarser toward bottom	15	145
CLAY, slightly sandy, reddish buff	9	154
CLAY, limy, compact, whitish buff	2	156
CLAY, sandy, very compact, hard, tan; cuts small pieces like sandstone	4	160
CLAY, sandy, limy, whitish; some scattered gravel	5	165
SAND, silty, reddish; some limy concretions or pebbles	8	173
SAND, fine and fine gravel (no sample)	7	180

	Thickness (feet)	Depth (feet)
GRAVEL, fine to medium, clean, light colored, red, yellow; some coarse	11	191
SHALE, dark gray; slightly greenish	9	200

34. Center NW¼ SE¼ Sec. 6,T.2 N.,R.19 W.; 50 feet north of fence in line with house, 0.3 mile west of house. Ground elevation, 2,000 feet (t); depth to water, 6.6 feet, November 11, 1939.

SOIL, sandy, dark brown	4	4
CLAY, gray	3	7
GRAVEL, fine, and sand, green	3	10
GRAVEL, fine to medium, green	5	15
GRAVEL, fine to medium, green; some clay and fine sand	5	20
GRAVEL, coarse, green	7	27
SHALE, gray to tan to green, sticky (Pierre)	2	29

35. Northeast corner of NE¼ SE¼ SE¼ Sec. 6,T.2 N., R.19 W.; 215 feet west of creek and 125 yards southwest of tile silo. Ground elevation, 2,005 feet (t); depth to water, 4.9 feet, November 11, 1939.

SOIL, fine, silty	2	2
SOIL, black	2	4
CLAY, sandy, silty, grownish gray	2	6
GRAVEL, fine and sand, red	4	10
GRAVEL, fine to medium, green	3	13
SHALE, greenish gray (Pierre)	4	17

36. SE¼ Sec. 8,T.2 N.,R.19 W.; 0.12 mile north of southwest corner of quarter. Ground elevation, 1,987 feet (t); depth to water, 7.3 feet, November 1, 1939.

SOIL and buff clayey sand	7	7
GRAVEL, fine and sand, reddish	5	12
GRAVEL, fine, greenish	17	29
GRAVEL, medium, greenish	11	40
SHALE, black (Pierre)	7	47

37. Northwest corner of SE¼ SE¼ SE¼ Sec. 8,T.2 N.,R.19 W. Ground elevation, 2,007 feet (t); depth to water, 29 feet, November 1, 1939.

SOIL and brown to buff clayey sand	14	14
SAND, clayey, buff	13	27
CLAY, silty, grayish brown	8	35
GRAVEL, fine to medium, reddish; some clay in sample, somewhat cemented	5	40
GRAVEL, medium to coarse, reddish	13	53
SHALE, blue gray, some black	6	59

38. NE¼ NE¼ Sec. 19,T.2 N.,R.19 W.; north side of highway, 50 yards south of railroad and 0.17 mile east of Republican River bridge. Ground elevation, 1,990 feet, (t); depth to water, 8.9 feet, October 24, 1939.

SOIL and fine sand	5	5
GRAVEL, fine, and sand, reddish	5	10
SAND, gray	5	15
GRAVEL, medium, some coarse; also water-worn shale	7	22
SHALE, greenish gray (Pierre?)	5	27

39. Center east edge NW¼ NE¼ Sec. 19,T.2 N.,R. 19 W.; 150 feet south of highway on west edge of road. Ground elevation, 1,985 feet (t); depth to water, caved at 11 feet, October 25, 1939.

SOIL, sandy, and fine slightly clayey sand	7	7
GRAVEL, medium; some coarse	4	11
GRAVEL, medium and sand	8	19
SHALE, black (Pierre)	6	25

40. NW¼ Sec. 19,T.2 N.,R.19 W.; 0.21 mile east of northwest corner of section on south side of road. Ground elevation, 1,995 feet (t); depth to water, 11.4 feet, November 6, 1939.

SOIL, black	5	5
SAND, clayey, brownish gray	4	9
GRAVEL, fine to medium, red	5	14
SHALE, black (Pierre)	5	19

41. SW¼ SE¼ Sec. 19,T.2 N.,R.19 W.; 80 feet north of Sappa Creek bridge, on east side of road. Ground elevation, 1,980 feet (t); depth to water, 11.4 feet, November 1, 1939.

SOIL	3	3
SAND, clayey, buff	8	11
GRAVEL, medium	7	18
CLAY, silty, blue; some gravel	2	20
GRAVEL, medium, greenish	8	28
CLAY, sticky, bluish gray	5	33
GRAVEL, medium to coarse	12	45
SHALE, black (Pierre)	4	49

42. Northeast corner of NW¼ NE¼ Sec. 20,T.2 N., R.19 W.; 90 feet south of highway and 0.28 mile west of northeast corner of section. Ground elevation, 1,990 feet (t); depth to water, 5.3 feet, October 25, 1939.

SOIL, silty	1	1
SAND, fine	4	5
GRAVEL, medium, reddish; some sand	6	11
GRAVEL, medium, grayish green	10	21
GRAVEL, slightly finer	4	25
GRAVEL, medium to coarse, green and red; finer at 31 to 34 feet	19	44
SHALE, black (Pierre)	5	49

43. Center NW¼ NE¼ Sec. 21,T.2 N.,R.19 W.; 0.07 mile west of house and 0.15 mile west of railroad junction. Ground elevation, 1,998 feet (t); depth to water, 31.3 feet, October 24, 1939.

SOIL and buff clayey sand	8	8
SAND, slightly clayey, brown	7	15
SAND, clayey, buff	9	24
SAND, finer than above; more clay 31 to 35 feet	11	35

	Thickness (feet)	Depth (feet)
GRAVEL, medium, reddish	5	40
GRAVEL, medium, reddish; some coarse	11	51
SHALE, black (Pierre)	5	56

44. SE¼ SW¼ Sec. 22,T.2 N.,R.19 W.; 95 feet north of railroad, on west edge of road intersection. Ground elevation, 1,980 feet (t); depth to water, 11.4 feet, October 21, 1939.

SAND, silty, brown	9	9
SAND, clayey, light brown	5	14
GRAVEL, medium, reddish	5	19
SHALE, greenish black (Pierre)	3	22
SHALE, gray (Niobrara?)	3	25

45. Southeast corner of NE¼ NW¼ Sec. 24,T.2 N., R.19 W.; 25 feet west and 45 feet north of Rope Creek bridge. Ground elevation, 1,990 feet (t), depth to water, caved at 12.8 feet, October 21, 1939.

SOIL	4	4
SAND, clayey, light brown	9	13
GRAVEL, medium, and sand	6	19
GRAVEL, coarse, reddish; some fine	9	28
SHALE, ochre colored and blue (Pierre - weathered)	4	32
SHALE, sticky, dark blue gray (Pierre?)	7	39

46. Southwest corner of NW¼ Sec.25,T.2 N.,R.19 W.; 110 feet north and 40 feet east of the southwest corner of quarter. Ground elevation, 1,988 feet (t): depth to water, dry at 22.7 feet, October 21, 1939.

SOIL	2	2
SAND, clayey, buff	14	16
SAND, clayey, brown	8	24
GRAVEL, coarse, reddish	12	36
SHALE, black (Pierre)	3	39

47. Southeast corner of NW¼ NE¼ Sec. 27,T.2 N., R.19 W.; 415 feet south of railroad underpass, on west edge of road and 60 feet south of old river channel. Ground elevation, 1,960 feet (t); depth to water, caved, October 21, 1939.

SOIL, silty, and fine sand	9	9
GRAVEL, fine	4	13
SHALE, dark blue gray (Pierre, Niobrara?)	6	19

48. Northwest corner of SW¼ SW¼ Sec. 27,T.2 N., R.19 W.; east edge of road, 0.37 mile north of river bridge. Ground elevation, 1,967 feet, (t); depth to water, 11.4 feet, October 24, 1939.

SAND, fine	5	5
CLAY, gray and silt	4	9
GRAVEL, medium, greenish gray	9	18
GRAVEL, medium to coarse, greenish-gray	20	38
GRAVEL, fine to medium, greenish-gray	7	45
GRAVEL, medium to coarse, greenish-gray	5	50
SHALE, black (Pierre)	2	52

	Thickness (feet)	Depth (feet)

49. Southeast corner of NE¼ NE¼ Sec. 28,T.2 N., R.19 W.; 0.22 mile south of section line, 90 feet west of road, on north edge of farm road. Ground elevation, 1,972 feet (t); depth to water, 10.2 feet, October 24, 1939.

SOIL, sandy	5	5
SAND, clayey, coarse	2	7
SAND and fine gravel	4	11
GRAVEL, fine to medium, greenish-gray	5	16
GRAVEL, medium to coarse, greenish-gray	5	21
GRAVEL, medium, some fine, greenish gray	13	34
SHALE, black (Pierre)	3	37

50. Southwest corner of NW¼ NW¼ Sec. 34,T.2 N., R.19 W.; 280 feet south and 115 feet east of river bridge, north edge of road. Ground elevation, 1,972 feet (t); depth to water, 19 feet, October 21, 1939.

SOIL	3	3
SAND, fine, clayey, buff	12	15
SAND, fine, and clay; sample hard to get, losing water	4	19
GRAVEL, fine to medium, gray	9	28
GRAVEL, medium; some clay	7	35
GRAVEL, medium, greenish gray	11	46
GRAVEL, medium to coarse	13	59
SHALE, black (Pierre)	3	62

51. NW¼ SE¼ Sec. 34,T.2 N.,R.19 W.; east edge of road, 0.08 mile north of road along valley edge. Ground elevation, 1,970 feet (t); depth to water, 21.5 feet, October 21, 1939.

SOIL, sandy	4	4
SAND, fine, clayey, buff	12	16
SAND, fine, limey, lighter color	5	21
GRAVEL, fine, reddish	6	27
GRAVEL, fine to medium, greenish	8	35
GRAVEL, medium	8	43
GRAVEL, medium, reddish; coarse 51 to 54 feet; some green gravel last 3 feet	11	54
SHALE, black (Pierre)	2	56

52. Northwest corner of Sec. 36,T.2 N.,R.19 W.; 25 feet south and 25 feet east of corner. Ground elevation, 1,951 feet (t); depth to water, 8.5 feet, October 24, 1939.

SAND, fine	5	5
GRAVEL, medium	7	12
SHALE, black (Pierre)	3	15

53. Center west edge of SW¼ NE¼ Sec. 36,T.2 N., R.19 W.; 45 feet east of one half mile line. Ground elevation, 1,945 feet (t); depth to water, 7 feet, October 24, 1939.

SOIL, sandy and fine sand	5	5
GRAVEL, fine and sand, reddish	5	10
GRAVEL, fine to medium, gray	5	15
GRAVEL, medium, some coarse, gray; some water-worn shale	4	19

	Thickness (feet)	Depth (feet)
SILT, carbonaceous, black	5	24
GRAVEL, fine to medium; dirty	11	35
SHALE, black (Pierre)	4	39

54. Northeast corner of SE¼ Sec. 36,T.2 N.,R. 19 W.; 125 feet west of section line. Ground elevation, 1,944 feet (t); depth to water, 7.3 feet, October 21, 1939.

SOIL and fine sand	5	5
GRAVEL, medium and sand, light colored	4	9
GRAVEL, medium, greenish gray	8	17
GRAVEL, medium, greenish gray; some coarse	18	35
SHALE, black (Pierre)	4	39

55. Southwest corner of Sec. 10,T.1 N.,R.19 W.; north edge of road, 160 feet east of corner. Ground elevation, 2,180 feet (t); depth to water, 96 feet, October 18, 1941.

SILT, buff (Peorian)	10	10
LOST WATER, poor sample, changed from buff to reddish buff in this interval	10	20
SILT and silty clay, reddish buff; has limy streaks and limy concretions	10	30
SILT and sandy clay, gray; concretions	5	35
CLAY, soft, tan	3	38
CLAY, indurated, tan; cuts in chips	14	52
SAND, brown to red; has a little clay	13	65
CLAY, limy to soft limestone; fairly hard	3	68
SAND, clayey, greenish gray; limy streaks	13	81
SAND, clayey, limy, whitish gray	3	84
SAND, clayey, gray	8	92
SAND, clayey, gray; sandy concretions or layers	4	96
CLAY, sandy, brown; indurated clay layers or thin seams	8	104
CLAY, soft, grayish tan	7	111
CLAY, tan; indurated layers	9	120
SAND and fine gravel, clayey, brownish gray	7	127
GRAVEL, fine to medium, light colored, clear greenish yellow, red	7	134
SAND, coarse, clayey gray	8	142
SAND and fine gravel	5	147
GRAVEL, coarse, sharp, mostly red; some clear	1	148
SHALE, light gray, rusty	6	154
SHALE, dark blue gray to black	13	167

56. Southwest corner of Sec.35,T.1 N.,R.19 W.; 85 feet east of corner on north side of road. Ground elevation, 1,980 feet (t); depth to water, 22.5 feet, October 9, 1939.

	Thickness (feet)	Depth (feet)
SAND, clayey, light brown	14	14
SAND, clayey, brown; coarser than above	7	21
SAND and fine gravel; some blue silty clay at 21 feet	8	29
GRAVEL, medium	6	35
GRAVEL, medium; some coarse with water-worn shale and chalk, also some soft shale pieces	6	41
SHALE, greenish black (Pierre)	5	46

57. Northeast corner of Sec. 25,T.4 N.,R.20 W.; 75 feet west of corner on south side of road. Ground elevation, 2,280 feet (t); depth to water, caved at 149.6 feet, October 18, 1941.

SILT, buff (Peorian)	27	27
SILT, dark brown to reddish (old soil)	3	30
SILT and silty sand, reddish buff	37	67
SILT and silty clay, reddish buff; limy streaks	5	72
CLAY, silty, limy, reddish buff to white	6	78
SILT, reddish buff; some limy concretions	6	84
SAND, silty, clayey, reddish buff; some red gravel	12	96
GRAVEL, medium to coarse, red; good	27	123
CLAY, silty, sandy, gray	4	127
SAND, silty, clayey, tan	5	132
SAND, coarse, clayey; cuts in large pieces	6	138
GRAVEL, fine to coarse, red	17	155
GRAVEL, fine to coarse, red; some black gravel	15	170
GRAVEL, medium to coarse; more coarse black gravel	8	178
GRAVEL, fine to coarse, pinkish to red; no black	10	188
CLAY, sandy, soft, tan	10	198
CLAY, limy, soft, whitish	4	202
CLAY, sandy, tan	4	206
GRAVEL, fine to medium, dirty	6	212
CLAY, sandy, reddish buff	3	215
GRAVEL, fine to medium, reddish; some tan sandy clay in upper part, poor	6	221
SAND, clayey, greenish gray	3	224
CLAY, sandy, hard, compact, limy, white	3	227
CLAY, sandy, greenish gray; some fine red gravel	8	235
CLAY, sandy, soft, greenish gray	11	246
GRAVEL, fine, red; some greenish gray sandy clay	14	260
GRAVEL, fine to medium, loose, red, clear	7	267
CLAY, gray; small amount of sand	4	271
GRAVEL, fine to coarse, red; good	15	286
GRAVEL, fine to coarse, red; about 1 foot of silty clay at 286 feet	4	290

	Thickness (feet)	Depth (feet)
SAND, clayey, soft, gray	4	294
GRAVEL, fine to coarse, loose, red, clear	25	319
SHALE, yellow, rusty to light steel gray		

58. Southwest corner of Sec. 15,T.3 N.,R.20 W.; 0.17 mile south of railroad and 12 feet east of section line. Ground elevation, 2,033 feet (t); depth to water, 11 feet, November 11, 1939.

SOIL and brown clayey sand	8	8
SAND and fine gravel	7	15
CLAY, black	3	18
GRAVEL, fine, muddy	5	23
GRAVEL, medium, reddish; some coarse, good	7	30
GRAVEL, slightly coarser than above; seems to be slightly cemented; some cemented sand	8	38
FLINT boulder, green; at 38 feet; rusty yellow shale below flint	5	43
SHALE, black	4	47

59. Southwest corner of NE¼ Sec. 16,T.3 N.,R.20 W.; 0.4 mile west of east section where cut by highway and 0.05 mile north of highway in southwest corner of hay flat. Ground elevation, 2,042 feet (t); depth to water, 8.8 feet, November 1, 1939.

SOIL	4	4
SAND, clayey, brownish gray	3	7
CLAY, silty, black to gray	8	15
GRAVEL, fine, and sand	5	20
GRAVEL, medium, loose, reddish; some sand	11	31
GRAVEL, medium, some coarse and compact sand, reddish	15	46
GRAVEL, flint; some limy shale	7	53
SHALE, limy, very light gray to white	7	60
SHALE, sticky, gray	4	64

60. SW¼ Sec. 18,T.3 N.,R.20 W.; 1/8 mile north and 260 feet west of southeast corner. Ground elevation, 2,041 feet (t); depth to water, 13.7 feet, November 6, 1939.

SOIL and buff clayey sand	12	12
SAND and fine gravel	8	20
GRAVEL, medium to coarse, greenish-gray; some clay at 25 feet	10	30
GRAVEL, coarse, green and red	5	35
GRAVEL, medium; more red than above	5	40
GRAVEL, medium to coarse, very compact, red; some sand	12	52
SHALE, ochre to greenish gray (Pierre?)	5	57

61. Center west edge of NW¼ SW¼ Sec. 23,T.3 N., R.20 W.; 115 south of railroad and 20 feet east of section fence. Ground elevation, 2,046 feet (t); depth to water, 29.2 feet, November 1, 1939.

SOIL	4	4
SAND, clayey, buff	23	27
MORE sand than above, darker brownish gray	7	34
GRAVEL, medium, compact, reddish; cemented	5	39
GRAVEL, medium, some coarse, reddish	9	48
SHALE, black (Pierre)	9	57

62. Southwest corner of SE¼ SW¼ Sec. 26,T.3 N., R.20 W.; 0.24 mile west of Carter bridge. Ground elevation, 2,015 feet (t); depth to water, 8.8 feet, November 1, 1939.

SOIL, sandy, and brown slightly clayey sand	7	7
GRAVEL, fine, and muddy sand	14	21
GRAVEL, fine to medium; some coarse gravel, coarser lower part	19	40
SHALE, greenish black (Pierre)	9	49

63. NW¼ Sec. 28,T.3 N.,R.20 W.; 425 feet south of northwest corner, east edge of road. Ground elevation, 2,032 feet (t); depth to water, 9.6 feet, November 6, 1939.

ROAD FILL	3	3
SAND, dark brown	2	5
SAND, clayey, buff to brown	7	12
GRAVEL, fine, and sand, red; coarser from 18 feet	12	24
GRAVEL, medium to coarse, red	5	29
SHALE, dark gray to greenish gray (Pierre?)	5	34

64. NE¼ Sec. 35,T.3 N.,R.20 W.; 0.12 mile west of northeast corner in south ditch. Ground elevation, 2,013 feet (t); depth to water, 8 feet, October 30, 1939.

SOIL and clayey sand	5	5
CLAY, silty, black	2	7
GRAVEL and sand	6	13
CLAY, blue	4	17
GRAVEL, coarse, reddish	9	26
SHALE, dark gray; some brownish gray; very hard to get sample, seemed to mix with mud	13	39

65. Southeast corner of NE¼ SE¼ Sec. 36,T.3 N., R.20 W.; 100 yards north of house and 0.15 mile south of railroad. Ground elevation, 2,013 feet (t); depth to water, 13.1 feet, November 1, 1939.

SOIL and brown clayey sand	9	9
SAND, clayey, buff	5	14
CLAY, silty, sandy, gray	7	21
GRAVEL, medium, reddish	10	31
SAND, clayey, yellow; cemented	2	33
GRAVEL, medium, light	4	37
SHALE, dark gray to black (Pierre?)	4	41

66. NW¼ Sec. 2,T.2 N.,R.20 W.; 0.33 mile east and 0.09 mile south of northwest corner, 50 feet west of river and 35 feet west of road. Ground elevation, 2,007 feet (t); depth to water, 6.7 feet. November 6, 1939.

SOIL and fine clayey sand	7	7
GRAVEL, fine to medium, and sand, red	4	11
GRAVEL, medium, greenish; somewhat dirty	8	19

	Thickness (feet)	Depth (feet)
GRAVEL, medium, green and red	5	24
GRAVEL, mostly coarse, more red; slightly finer at bottom	22	46
SHALE, dark gray to black	3	49

67. South edge of NE¼ SE¼ NW¼ Sec. 12,T.2 N.,R. 20 W.; 50 feet north of road and 100 yards north of house. Ground elevation, 2,010 feet (t); depth to water, 16.8 feet, November 6, 1939.

SOIL and light brown clayey sand	15	15
SAME as above but finer and softer	5	20
SILT, blue black	2	22
GRAVEL, medium, greenish	3	25
SHALE, light blue gray; some dark	4	29

68. West edge of NE¼ SE¼ NE¼ Sec. 12,T.2 N.,R. 20 W. Ground elevation, 2,000 feet (t); depth to water, 9.7 feet, November 6, 1939.

SAND, fine; from flood	3	3
SOIL	3	6
SAND, clayey, buff	2	8
CLAY, gray	2	10
GRAVEL, medium and sand	8	18
GRAVEL, medium to coarse	14	32
SHALE, black (Pierre)	5	37

69. Northeast corner of SE¼ Sec. 16,T.2 N.,R.20 W.; west edge of road. Ground elevation, 2,046 feet (t); depth to water, dry at 36.5 feet, November 1, 1939.

ROAD FILL	3	3
SAND, clayey, buff to yellow	16	19
SAND, clayey, brownish yellow	10	29
GRAVEL	6	35
GRAVEL, medium to coarse, compact, red; a little clay present	5	40
GRAVEL, coarse, compact	7	47
GRAVEL, slightly finer than above, reddish; some clay	4	51
SHALE, black (Pierre)	3	54

70. Southwest corner of Sec. 17,T.2 N.,R.20 W.; on bank east side of road and 110 feet north of corner. Ground elevation, 2,064 feet (t); depth to water, 35 feet, November 1, 1939.

SOIL	3	3
SAND, clayey, buff to yellow	18	21
SAND, clayey, brownish red	6	27
GRAVEL, medium, reddish	6	33
GRAVEL, medium to coarse; large pieces brown jasper	10	43
SHALE, dark gray at 43 feet; yellow rusty shale pieces and jasper	5	48

71. SW¼ NW¼ Sec. 20,T.2 N.,R.20 W.; in east ditch, 90 feet south of Sappa Creek bridge. Ground elevation, 2,015 feet (t); depth to water, 9.4 feet, November 1, 1939.

SOIL and clayey sand	7	7
GRAVEL, medium to coarse, reddish; large pieces water-worn shale and jasper	7	14
GRAVEL, coarse, greenish; large pieces	6	20
GRAVEL, fine to medium, gray; dirty	10	30
GRAVEL, fine; some coarser	8	38
SHALE (?), dark gray; few small pieces; at this point drilled like shale, but upon making pipe change, bit plugged	1	39

72. Northeast corner of Sec. 23,T.2 N.,R.20 W.; west edge of road, 105 feet south of highway. Ground elevation, 1,995 feet (t); depth to water, 12.6 feet, October 26, 1939.

SOIL and lime slightly clayey sand	8	8
SAND; a little gravel	6	14
GRAVEL, fine and sand	5	19
GRAVEL, medium, well sorted, green	4	23
GRAVEL, medium, some coarse; from 23 to 25 feet, much water-worn shale and some sticky gray clay	6	29
SHALE, black (Pierre)	3	32

73. Southeast corner of NE¼ NE¼ Sec. 23,T.2 N., R.20 W.; west edge of road, 0.1 mile south of Sappa Creek bridge. Ground elevation, 1,992 feet (t); depth to water, 11.5 feet, October 26, 1939.

SOIL, dark brown and fine clayey sand	5	5
SAND, clayey, brownish gray	4	9
GRAVEL, medium, some fine; also large pieces	5	14
GRAVEL, fine to medium; some large gravel	5	19
GRAVEL, fine, and sand; muddy	7	26
SILT, blue, and clay	3	29
GRAVEL, medium to coarse; good	5	34
SHALE, black (Pierre)	3	37

74. Center west edge of NW¼ SW¼ Sec. 24,T.2 N., R.20 W.; 0.36 mile north of section corner. Ground elevation, 2,005 feet (t); depth to water, 24 feet, October 26, 1939.

ROAD FILL	2	2
SAND, fine, clayey, light brown	16	18
SAND, fine, clayey, sticky, reddish	10	28
SAND, silty, blue	2	30
GRAVEL, fine to medium, reddish	5	35
GRAVEL, fine to medium, greenish; some sand; drilled like coarse gravel present	28	63
SHALE, black (Pierre)	4	67

75. NE¼ Sec. 27,T.2 N.,R.20 W.; on bank, west side of road, 0.21 mile south of northeast corner. Ground elevation, 2,039 feet (t); depth to water, dry at 30 feet, November 1, 1939.

SOIL and clay	4	4
SAND, clayey, brown to buff	16	20
SAND, clayey, slightly darker	8	28
SAND, clayey, gray, lower part rusty sand (Fossils)	8	36
GRAVEL, fine compact, reddish; some coarser gravel (cemented?)	8	44
SHALE, black (Pierre)	5	49

LOGS OF CORE-DRILL HOLES DRILLED IN HARLAN COUNTY
BY THE CORPS OF ENGINEERS, U. S. ARMY

A-1 NW¼ Sec. 2,T.1 N.,R.17 W.; 0.2 mile south and 0.2 mile east of northwest corner of section. Ground elevation, 1,995 feet (t); depth to water, not measured.

LOAM, silty, clay	12	12
LOAM, clayey	19	31
LOAM, sandy	9	40
LOAM, silty clay	9	49
LOAM, sandy clay	13	62
LOAM, sandy	8	70
SAND	13	83
CLAY, medium	8	91
SHALE, medium hard, silty, calcareous	50	141

A-2 NW¼ Sec. 11,T.1 N.,R.17 W.; 0.4 mile south and 0.4 mile east of northwest corner of section. Ground elevation, 1,885 feet (t); depth to water, not measured.

LOAM	3	3
LOAM, silty	2	5
SAND	3	8
SAND, gravelly	2	10
CLAY, lean	3	13
SHALE, soft, silty, calcareous	43	56

A-3 NW¼ Sec. 14,T.1 N.,R.17 W.; 0.5 mile south and 0.4 mile east of northwest corner of section. Ground elevation, 1,995 feet (t); depth to water, not measured.

LOAM, clayey	2	2
LOAM	6	8
LOAM, silty	1	9
LOAM, clayey	2	11
LOAM	4	15
LOAM, clayey	4	19
LOAM, silty clay	3	22
LOAM, sandy	7	29
SAND, gravelly	5	34
SAND	8	42
CLAY, medium	10	52
CLAY, lean	6	58
SHALE, medium hard, waxey	68	126

A-4 SW¼ Sec. 33,T.1 N.,R.19 W.; 0.5 mile north and 0.15 mile east of southwest corner of section. Ground elevation, 2,100 feet (t); depth to water, not measured.

LOAM, silty clay	5	5
LOAM, silty	20	25
CLAY, lean	6	31
LOAM, sandy	7	38
CLAY, lean	9	47
LOAM, silty clay	7	54
CLAY, lean	12	66
SAND	13	79
LOAM, sandy clay	6	85
CLAY, lean	9	94
SHALE, medium hard, waxey	43	137

A-5 SW¼ Sec. 33,T.1 N.,R.19 W.; 0.1 mile north and 0.15 mile east of southwest corner of section. Ground elevation, 2,015 feet (t); depth to water, not measured.

LOAM, sandy	3	3
LOAM	9	12
CLAY, lean	5	17
LOAM, clayey	7	24
LOAM, silty	8	32
LOAM, silty clay	11	43
LOAM, sandy	4	47
CLAY, medium	4	51
SHALE, medium hard, silty, calcareous	31	82

(t) Elevations estimated from topographic map.
(a) Elevations obtained by altimeter levels.
(i) Elevations established by instrumental levels.